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Editorial Notes

Development of the Port of Rotterdam

Which is the world's greatest port? Such speculation may appeal to the popular imagination but it is incapable of being resolved for there is no satisfactory criterion by which precedence can be established. Visitors will be told with understandable pride that Rotterdam is the second largest. Yet the development of the Europort programme, one phase of which is discussed in an article we print in this issue, is indeed likely to place the matter altogether beyond dispute, whatever standards we choose to adopt. Size, of course, is not everything, though notable economies ought to flow from the planning of large-scale operations where the volume of commerce is sufficient to allow ocean carriers to make an optimum use of their own alongside facilities. Certainly, treating a marine terminal primarily as a point of interchange between inland and ocean carriers, such interchange should be straightforward and direct: a single point for preference, not two.

In Rotterdam, the area of the port administration's authority has been transformed into a vast industrial and trading estate. The main arterial approaches (the New Waterway and the Maas) leading from the Hook and communicating with the navigable channels of the Rhine basin, form part of the national rivers and waterways system of the Netherlands. The channels and basins and land property forming the site of the harbour installations and their associated industries are municipalised, and their reclamation, conservation and control is exercised by the Municipal Management Department of the city corporation, which in every sense functions as the planning and administrative authority of the port. The Authority does not enter into wharfinger activities and rarely does it provide quay structures itself, either for ocean carriers or for industrial concerns. It construes its duties as those of furnishing basic common-user facilities for adaptation by private developers. The art of terminal administration is the striking of a correct balance between excessive regimentation and unregulated laissez faire. It is quite proper that some phases of a complex enterprise should be more profitable than others, but each should pay its own way. There is no more equity in having one tariff actively support another than in having a non-utility undertaking carry a utility business or, in fact, having a utility business support a private venture. The Port of Rotterdam has an enviable reputation everywhere and it would be extremely valuable to have its attitude towards these fundamental questions described.

The outstanding development of Rotterdam since the war reflects not only the revival of the West German economy but also the growth of industrialisation in the Netherlands itself, largely influenced by the Benelux customs union. The complete liberalisation of the three countries' economic, financial and fiscal policies has proved a difficult task, the more so since this is a voluntary economic coalition without any supra-national structure. Nevertheless, all industrial products except nitrogen fertilisers and rough diamonds are fully liberalised in intra-Benelux trade. Customs duties have disappeared. Benelux has a common outer tariff. Only about two per cent of all goods traffic can still be made subject to quotas and special regulations. There is almost complete co-ordination of trading policy and nearly every trade pact is now concluded in the name of Benelux. The members of the European Community no doubt feel encouraged to believe that the same prescription will prove equally effective in a wider ambit, though it is inescapable that the wider the area the more numerous will be the points of dissidence and of friction. For example, the Benelux countries are convinced free-traders, an attitude which is by no means altogether acceptable to the Six.

However this may work out, the authorities at Rotterdam are determined that with any resurgence of trade through economic integration their port shall maintain its supremacy as the principal service station linking the Community with the outer world. An examination of the tables given in the article (presumably all reduced to weight tons and NRT) shows that although the volume of general cargo has approximately doubled since the war and dry cargo in bulk remains almost unchanged, by far the greatest impact has been the growth of oil entrepot traffic which now stands at 34 million tons where little existed previously. The increase in shipping movements is largely attributable to this source. The Botlek development is of course primarily directed to servicing this traffic and in this connection it is significant that whereas in 1950 only 12 vessels with a draft exceeding 34-ft. 6-in. entered or left the port, this number had increased to 150 in 1957. Accordingly, another phase of development has been the deepening of the New Waterway to make the three oil harbours accessible to vessels with a maximum draft of 39-ft. But later phases of the Europort project (the Delta Plan) will involve large reclamations at the seaward end and the opening up of new basin areas, initially to be approached by way of the New Waterway, but which, along with other harbours of the Europort system, will eventually be linked directly with the sea. This may necessitate the introduction of locks designed to limit the penetration of sea water too far inland. The progress of these vast new enterprises will be watched with the closest interest.

Development of the Port of Ashdod

As briefly announced in our August issue, the World Bank has granted a loan of $27½ million to Israel for the construction of a deepwater port at Ashdod, some 18 miles south of Tel-Aviv. The site is in a relatively open area well suited to development, and will be linked by road and rail to the productive areas now served by Tel-Aviv and Jaffa. When completed in 1965, the new port will be able to handle twice as much traffic as these two lighterage ports are accommodating at present and so will be able to relieve the congestion at Haifa.

The port Ashdod will comprise a basin protected by breakwaters, with finger piers projecting into the sheltered water area. It will be constructed in stages, the second stage to be undertaken when growth of traffic justifies it. The first phase includes the construction of the breakwaters, approximately two miles in all; dredging of the port area; construction of three piers, each of which will be able to accommodate five ocean-going ships at one time; the provision of tracks and roadways within the port area and rail links outside it; transit sheds for general cargo and citrus fruit and paved open storage areas; port utilities and auxiliary structures; and the supply of harbour craft, cranes and mobile loading equipment. It is estimated that Ashdod should be ready to handle citrus fruit shipments and some general cargo by 1964.

It is reported that the Government of Israel intends to establish early in 1961, a Port Authority which will be an autonomous public enterprise responsible for the construction, operation and development of all Israel's port facilities. This Authority will take over the task of constructing the port of Ashdod which is now under the jurisdiction of the Ministry of Transport and Communications. Consulting engineers in co-operation with the Israeli authorities will supervise the work and all major contracts will be awarded through international competitive bidding. The total cost is estimated to be equivalent to $54.7 million of which the Bank loan will cover all the foreign exchange requirements, the remainder being met by the Government of Israel. Arrangements will be made to set aside from port revenue sufficient funds to amortize the loan.

Jetty for Milford Haven Conservancy Board

Milford Haven, one of the finest natural harbours in this country and, indeed, in the world, is now being used by large oil tankers as the new Esso and BP terminals come into operation.

In order to regulate the development of the area and control shipping in the Haven, the Milford Haven Conservancy Board was set up by Act of Parliament in 1958—the only new conservancy board to be set up in the present century. The Board has lost no time in taking up its heavy responsibilities and equipping itself to cope with the extensive maritime traffic which is expected to develop rapidly. This demands that the Board should operate a small fleet of launches, 24 hours a day and 365 days a year. Whatever the weather and state of the tide, pilots, customs officials, the Board's officers and others must be able to put out in their launches in safety.

The Board decided to appoint consulting engineers to advise it on all matters concerning the civil engineering aspects of the Board's operations; the consultants, Posford, Pavry & Partners of Westminster, were therefore instructed to investigate and report upon the provision of a suitable base for operating these launches, as there are at present no facilities for landing in rough weather at low tide in the lower part of the Haven. The consultants recommended that a new jetty should be built on the North shore of the Haven near Fort Hubberston.

The works will comprise an approach road down the hillside and an approach jetty 300-ft. long leading to a jetty head. One arm of the L-shaped jetty head forms a 100-ft. long protective extension to the approach jetty; the seaward arm, lying parallel with the shore is 230-ft. long, and the two arms together provide an adequate area of protected berthing on the inside while unprotected berthing is available on the outside. The two arms of the jetty head are aligned in such a manner that launches berthing on the inside will obtain protection from south westerly and south easterly seas. The approach jetty consists of a concrete deck structure on precast piles and has a carriageway width of 10-ft. 6-in. between handrails.

The pier head structure consists of three reinforced concrete pontoon foundation units, which are to be built in a dry dock and towed to the site by tugs. When aligned in their proper positions, the pontoons will be allowed to settle on to the sea bed where they will be temporarily steadied by four steel piles in such a way that the top of the pontoon walls will be horizontal and at a level above that of low water neap tides. Precast concrete piles will then be driven to rock through slots already provided in the pontoons to which the driven piles will be connected, so making a very stable monolithic base to the structure. The road deck on the pier head will be 21-ft. wide and will be at a height of 6-ft. above maximum high water. It will be supported by precast concrete diaphragm walls erected on the top of the foundation units. A steel sheet piling wall will then be fixed between the deck and the top of the foundation units along the seaward sides of the two arms of the pier head. This sheet piling will complete the protection of the inside of the jetty against wind and sea.

Model Investigation for Dover Car Ferry Service

In view of the rising totals of accompanied cars passing through the port, the Dover Harbour Board is considering plans to double the number of car ferry berths at their Eastern Dock. To ensure that the most suitable site will be chosen, having regard to prevailing winds, the Board recently gave instructions through their consulting engineers Messrs. Coode and Partners, London, for a model investigation to be made in connection with the design of the proposed new works. A 1/100th natural scale model of the harbour has accordingly been built in a wave basin at the Wimpey Central Laboratory, Hayes, Middlesex.

Wave generators are used to propagate waves through the harbour entrances and the resulting wave heights and ship movements are being recorded as part of a comprehensive engineering study. The investigation has included site surveys in which up to 15 observers have been engaged upon recording wave and sea conditions and these observations have been used to compare the behaviour of the model with prototype phenomena.

An attempt to obtain some assessment of navigational problems is also being made independently by the Central Laboratory using a newly-developed radio-controlled model vessel in the harbour.

The number of vehicles transported across the English Channel has grown continuously in recent years. The total passing through Dover in both directions in 1959 was 292,194, compared with 245,720 in 1958 and 197,419 in 1957. The figures for 1960 already show a rise of about five per cent over the corresponding period of 1959.

Reconstruction of Belfast Oil Berths

Belfast Harbour Commissioners, who recently approved a £1 million scheme for a new deep-water wharf in the Victoria Channel and the reconstruction of quays for the Dufferin and Spencer docks, have also decided to reconstruct the oil berthage accommodation on the east side of the Musgrave Channel. For the latter scheme tenders are now being sought and the closing date is September 26.

The improvement of the oil berthage accommodation is necessitated by the growth of the port's imports of petrol and oil and the expansion of the installations of the major oil companies.

The Post-War Development of the Port of Rotterdam

With Particular Reference to the Botlek Harbour

by Ir. Tj. J. RISSELADA
Deputy Managing Director, Gemeentelijk Havenbedrijf, Rotterdam.

THE port of Rotterdam is an outstanding example of a municipal port. The Municipality owns and controls all the quays and the land areas and sites as well as the whole of the water areas apart from the state owned "Nieuwe Maas" river and its mouths, the "Nieuwe Waterweg" forming part of the national rivers and waterways system.

The great majority of the quays and sites are let to private enterprises on long leases.

In addition to the normal administration of the port the Municipal Management Department has the task of planning new extension schemes to satisfy the increasing demands of the private concerns.

As the layout of the port is closely related to the development of the adjacent areas and must fit in with the national road and waterway system, extension plans are worked out in close co-operation with the Town Planning Department and thereafter submitted for approval to the provincial and state authorities for incorporation into provincial and national master plans.

The design and execution of the works required for such extension schemes as well as for smaller improvements and normal maintenance is the responsibility of the Municipal Technical Department.

Historical Background

Beginning as a fishing hamlet many centuries ago,* Rotterdam gradually developed into a commercial port as a result of its favourable situation on the estuary of the rivers Rhine and Meuse—at that time the principal transport routes—and of its open communication with the sea.

For centuries the struggle to maintain easy access to the sea has continued in view of the serious consequences of silting, due to tidal action and to changes in the regime of the estuary. All the time and especially in the last 100 years, this struggle against natural forces has been aggravated by the ever increasing size of ships.

The rapid expansion of industry in Western Germany since the second half of the last century, has been largely responsible for turning Rotterdam into a great and modern port. Its growth is illustrated in the three plans of the years 1850-1900-1940 (Fig. 1). In the latter year on the western boundary of the port, a very modest oil port will be noted. The number and tonnage of the incoming ships in those years increased as follows:—

Year:	Number of Ships:	Nett. Reg. Tons:
1850	1940	350,000
1900	7268	6,330,000
1938	15360	24,722,000

The second world war left the once prosperous port severely damaged; bombing and demolitions had played havoc with quay-walls and installations, while many scuttled ships blocked the channels. Not only were many activities of the port more or less paralysed, but also, in view of the destruction and dislocation of industry in the greater part of Rotterdam's natural hinterland, the outlook seemed far from bright.

Yet, in spite of all these discouraging circumstances, energetic and widespread efforts were made to achieve a quick and efficient rehabilitation and in consequence, by the end of 1949, the reconstructed port was taken over from the contractors.

Thanks to Marshall Aid, the economic recovery of Europe, began already to bear fruit. The restoraton of Western Germany as an important European partner and the increasing industrialisation of the Netherlands were factors which strongly contributed to the development of the port, the growth of which can be clearly illustrated by continuing the table shown above:—

Year:	Number of Ships:	Nett. Reg. Tons:
1952	15,443	25,400,000
1954	18,024	32,800,000
1956	21,239	43,300,000
1958	21,956	48,500,000

These figures demonstrate that the postwar development was more than a mere come-back and that appropriate measures would need to be taken to provide for this development to which among others European integration and the Common Market gave (and still give) an important impetus (Fig. 1 Situation 1960).

General Considerations

An important factor in the growth of Rotterdam has been the fact, mentioned above, that in its hinterland great industrial development came into existence, requiring the import of large quantities of bulk goods, such as iron and coal, while a great variety of industrial commodities became available for export.

Geographically Rotterdam is fortunate in possessing a very favourable location near the mouth of a great international waterway, the Rhine, leading directly into the heart of the industrial centres of West Germany and, thanks to the canalisation of the Meuse, the Mosel, the Main, the Neckar and the Upper-Rhine, to Eastern Belgium, Luxemburg, N.E. France, Southern Germany and Switzerland (Fig. 2).

It is linked with the North Sea by an open tidal channel, called partly "Nieuwe Waterweg," partly the "Scheur" and partly the "Nieuwe Maas," of such dimensions as to enable the largest ocean-going vessels to reach the port without difficulty.

Furthermore it should be noted that the Netherlands succeeded in developing the area of the Rhine-Meuse estuary, to enable it to function as an international seaport not merely by equipping it as an efficient loading and unloading centre, but also, by providing it with all the facilities of a modern port and by making it a centre of industry and commerce. Rotterdam had learnt by centuries of experience, how to adapt itself to new situations; its relatively simple administration has enabled it to maintain a flexible and efficient management. Moreover it knew that it was imperative to look ahead and to

* A short historical outline was given in this Journal Vol. XXXII, Aug. 1957, by Mr. W. H. Crawford.

discover what the trends of economic evolution might be, in order to pursue a coherent long-term policy.

It is of course essential to have sufficient confidence and courage to take the appropriate measures and to plan ahead so as to meet future demands as they arise. These plans sometimes require investments of several millions of pounds; wrong assessments can mean enormous financial losses, while opportunities can be lost if development has been allowed to lag.

It is the task of management to plan ahead, make the necessary decisions and organise construction at the proper time. However, it must be acknowledged that good luck sometimes enters into these decisions, when, for instance, some particular political circumstance encourages specific industrial development.

The oil conflict in Iran as well as the Suez crisis were responsible for giving a special impetus to the Botlek-Plan and the Europoort-Plan respectively to an extent which will be described later. The finding of the funds, necessary to carry out extensions and improvements, is a municipal affair. The State Government only contributes where the national importance of the works is evident e.g. the new mouth of the Europoort.

Though Rotterdam has a balanced annual budget and therefore is enabled to obtain loans on the public market, the investments needed for such schemes might become an excessive financial burden were it not for the custom that has grown up for the participation of private enterprise.

Hence the Municipality has generally concentrated its responsibility upon the provision of the basic elements, comprising the canals, the docks, the sites, the revetment of slopes and if required for certain trades, the quay walls. The "superstructures" e.g. sheds, warehouses, silos etc. then become, with a few exceptions, the concern of private enterprise. Similarly the industrial companies are building their own berthing structures.

As shipping is so sensitive to economic fluctuations, it is of vital importance for a port to make its trading basis as broad as possible. In the first place therefore, a port should try to provide a wide range of facilities to attract both general cargo trade and the widest possible variety of bulk cargo. A shipbuilding and repair industry, equipped with dry docks of various sizes, is also of the greatest advantage. In the second place industrial development based on imported raw materials is essential, preferably accompanied by related secondary industrial undertakings in the near vicinity.

As regards Rotterdam, its previous narrow trading basis was widened by encouraging the flow of general cargo which was facilitated by the post-war industrialisation of the Netherlands. These developments also made the port less dependent upon the German hinterland.

Before the war the "national" traffic in the port amounted to not more than 20% of the total seaborne trade; at present this percentage is more than 60% (Fig. 3).

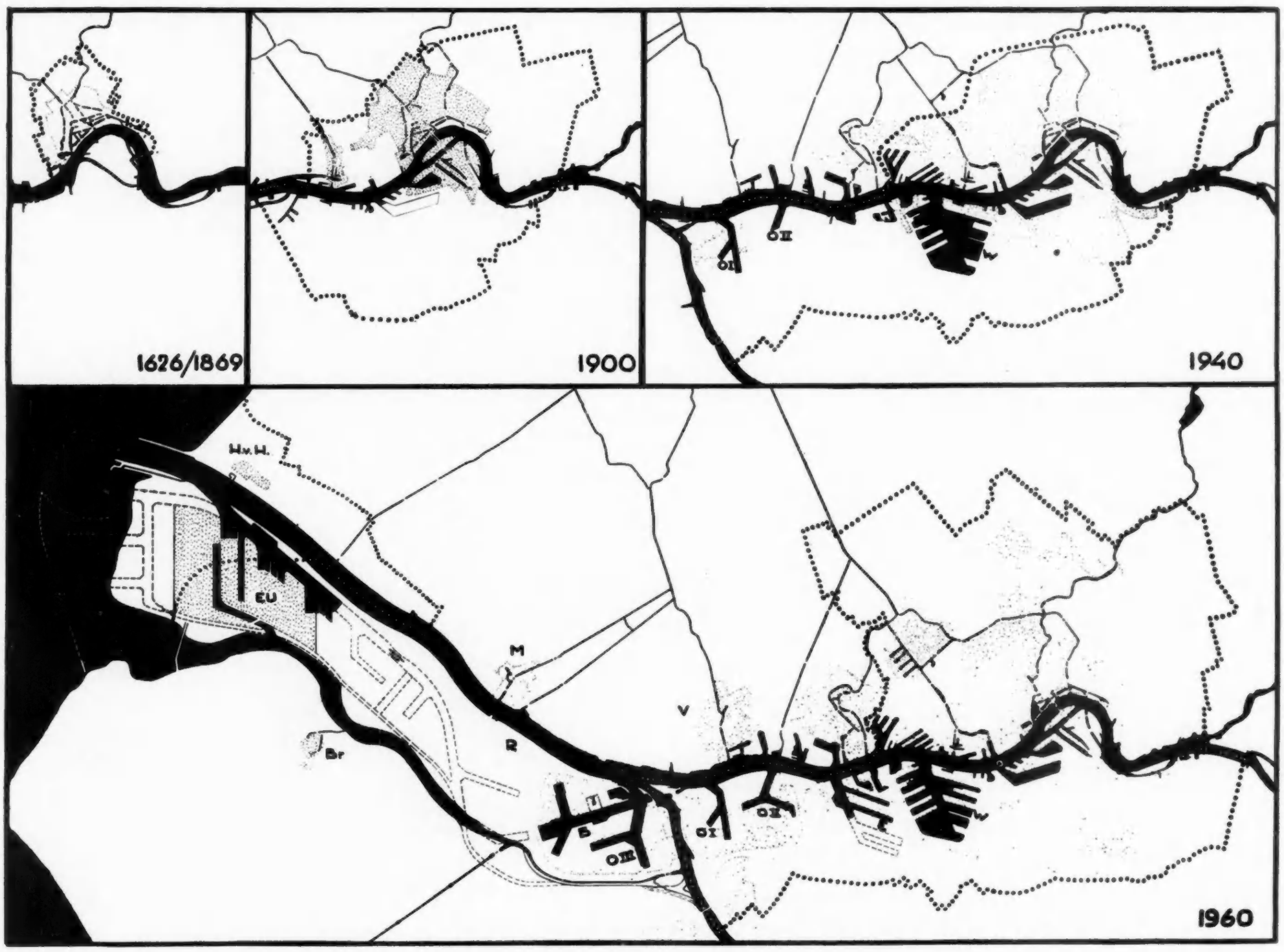


Fig. 1. Plans of the Port of Rotterdam at different epochs.

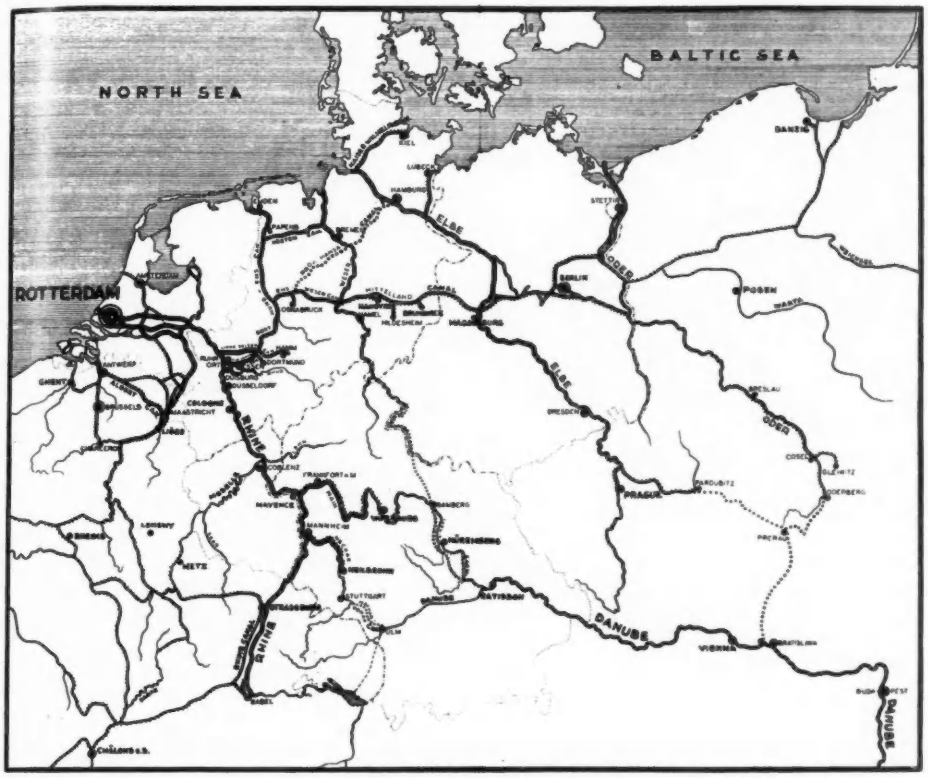


Fig. 2. Hinterland of Rotterdam.

Furthermore, a good deal of attention was given to the creation of suitable conditions for the establishment of waterside industries. As a result of the big strides made by petrochemical science, a great expansion took place in this industry for which sites had to be prepared in the shortest possible time.

The development of trade after the second world war is illustrated by the graph in Fig. 3 whilst Fig. 4 shows the flow of the 1959 goods traffic to various destinations.

Post-war Extensions

It is evident that the increase in post-war traffic was bound to necessitate major expansion projects.

To satisfy the demand for more general cargo facilities, it was possible to build more piers in the eastern part of the Waalhaven (marked W in Fig. 1). Further west, more extensions will soon be carried out in the Eemhaven (marked E in Fig. 1).

For the expansion of the oil industry, there was at the end of the war still plenty of room available at the sites around the first oil port near Pernis (Fig. 1-O1) where the Royal Dutch Shell Co. had founded their refinery in 1936. Moreover, a site for a second oil port (Fig. 2-OII) slightly to the east was available for development. This area has now been developed for petrochemical industries and for a refinery for the Caltex Co.

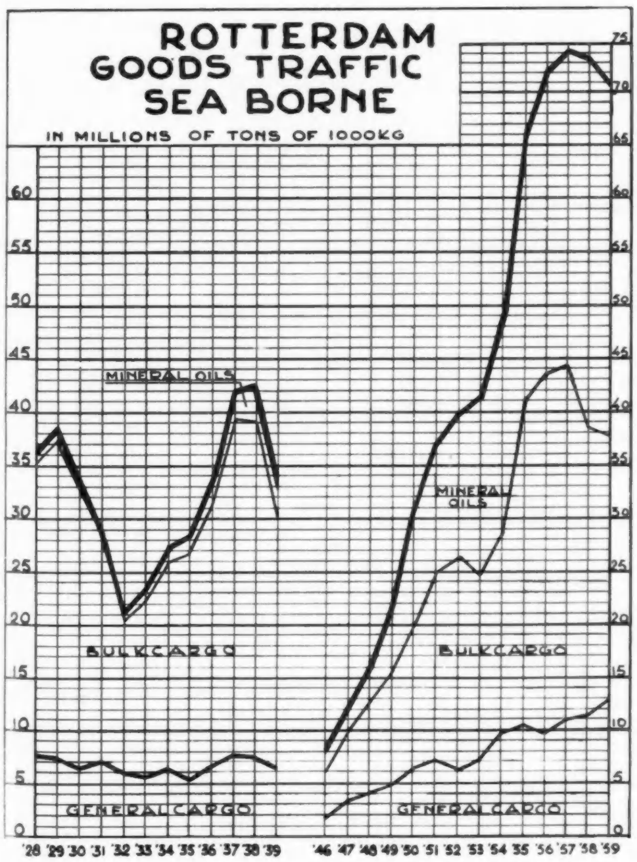


Fig. 3.

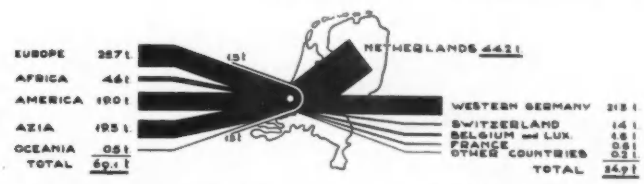


Fig. 4. Seaborne goods traffic in the Pcrt of Rotterdam, 1959, in millions of tons (of 1,000 KG).

However, in order to satisfy the demands for industrial sites located near deep water with ancillary facilities, it became necessary to open up entirely new areas. Such areas could only be found west of the existing oil ports. And thus the Botlek plan was conceived.

The Botlek Plan

In actual fact the conception of this plan originated during the last war and it was published in its original form in 1947 (Fig. 5). The object of the plan was to create an area with good accessibility for deep-draft ships (38-ft. to 39-ft.), and with good road and rail communication with the hinterland.

This scheme required, in the main, the conversion of the Botlek a former branch of the river " Nieuwe Maas " into a harbour and the transformation of the adjacent land areas into industrial sites. A group of locks was designed to close the Botlek near its diversion from the " Nieuwe Maas " in order to limit the amount of salt water penetrating inland. To make this area accessible for road and rail traffic, it was necessary to build a lifting bridge across the " Oude Maas ", as soon as possible. The construction of this bridge with a clear height of 45 m. (150-ft.) was started at the end of 1952 and completed early in 1955. After some

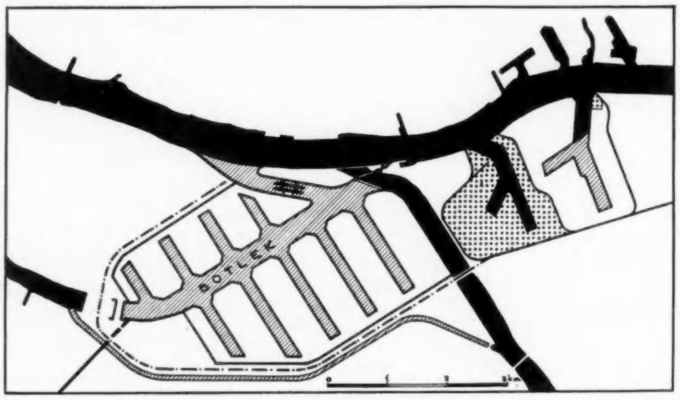


Fig. 5. Botlek Plan 1947.

preparatory work had been done during 1954 a start was made in 1955 with the dredging and reclamation.

However during the period required to obtain possession of the land by compulsory purchase, some fundamental alterations regarding the allocation of this area took place due to the rapid expansion of the oil industry. Apart from the general increase in energy requirements, the changeover from solid to liquid fuels contributed enormously to the increase in oil consumption. In addition, a change of policy arose, regarding the best location for the oil refining industry. Previously it had been customary to build the refineries near the oil fields in order to obtain the maximum economy of production and transport. Following the difficulties with Iran, which led first to a restriction and later to a complete stoppage of all deliveries from the refinery at Abadan (which is one of the largest in the world) it was decided to increase the refining capacity in consumer countries, which meant enlarging existing refineries and building new ones. This inevitably affected the expansion schemes of Rotterdam and although the Botlek area was not initially intended for the oil industry, the plans had to be reconsidered and adapted to the new demands. The eastern part was therefore designated as an oil port, (called the third oil port). To provide free access for the tankers entailed the shifting of the locks westwards (location marked on map Fig. 6 with X), thus forming a separation between the easterly oil area and the westerly industrial area.

The advent of the Delta Plan finally made it possible to omit the locks entirely and permit a direct connection with the "Nieuwe Waterweg" and whereas the changed form of the plan arose from broad economic factors, the final shape resulted from the outcome of negotiations with the various tenants about the most suitable situation of their premises (Fig. 7).

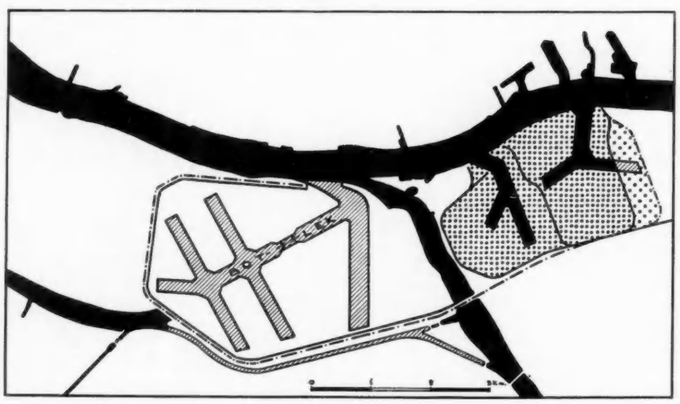


Fig. 6. Botlek Plan 1953.

Since at the outset only a limited number of occupants are known it requires a great deal of flexibility in the plan to allow for the latecomers and it may be necessary to make some re-allocations.

As regards the technical aspects, the total area comprises 3,400,000 acres (1,350 ha) of which 1,950,000 acres (780 ha) are available for private enterprise, 775,000 acres (310 ha) for public services and utilities such as roads, railways, cable and pipeline reservations etc., whilst 650,000 acres (260 ha) are taken up by the harbour basins.

As shown in cross-section (Fig 8), the original terrain level was located at 0.70 M + N.A.P. (Datum) the new level at 4.50 M + N.A.P. (Datum).

The depth of the basins averages about 12 m. (39-ft.) at L.W., while in some places, where deep-draft tankers will berth, the depth will be greater. The tidal range averages 5-ft.

The total length of the banks amounts to 11 miles. Where wave and wash attack can be expected, the slopes are faced with basalt above which concrete blocks are used to prevent erosion by surface water.

The total quantity of sand, needed for hydraulic fill amounted to 35 million m³ which was mostly obtained from the dredging of the basin.

Dredging was done partly by bucket dredger, but where feasible suction dredgers were employed, pumping the material directly by pipeline into its place.

The dredging and filling work was started in 1955 and in 1957 the first seagoing vessel was able to enter the area to discharge

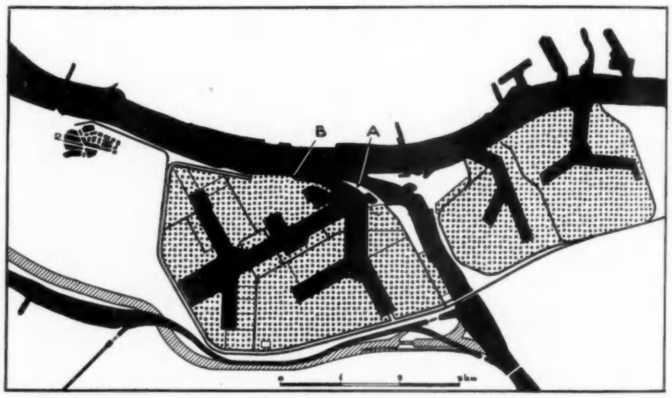


Fig. 7. Botlek Plan 1958.

its load. The works were carried out in such a way as to enable the tenants to start building activities as soon as possible, thus speeding up the utilisation of the area. This explains, why, for instance, when the groundwork of the Botlek project is only just nearing completion, a big enterprise such as the Esso refinery has been in production for some time, some tank storage firms are already working at full capacity and at Verolme Shipyard various ships have been launched, while the facilities were still under construction.

Special attention was given to the shape of the entrance: firstly to prevent disturbance of the flow pattern in the river, secondly to give shipping a safe and easy passage and thirdly to reduce siltation. To this end the tongue of land marked A (Fig. 7) has been shortened by some 180 m., thus reducing considerably the movement of water. At B (Fig. 7) the riverbank is given a sharp bend in order to make the flow pass by, rather than enter the harbour mouth.

From a technical point of view the set up of a modern ore storage site might be noteworthy.

The ore coming from Labrador and other far-off regions is

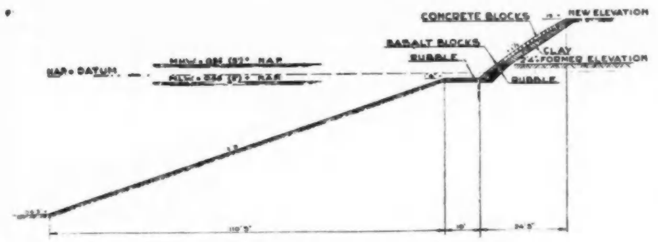
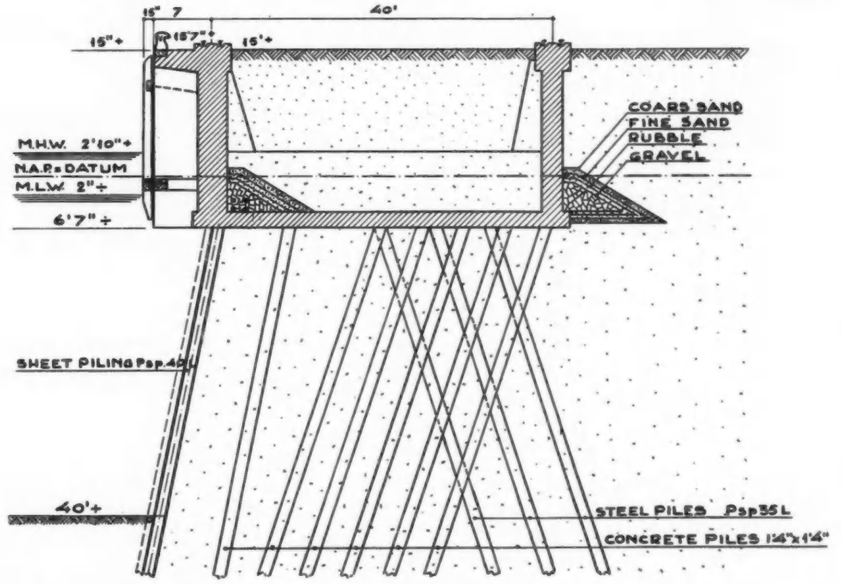


Fig. 8. Cross-section of 3rd Oil Harbour.

The piles driven with a batter of 3:1 backwards, are likely to be subjected to more serious bending due to their position. Therefore the adaption of steel piles was favoured and single Peine section Psp 35L, allowing for a pull of 20 tons (with an ample safety margin) were used.

Driving the sheet-piling at an inclination has several advantages. The sheet piling takes part of the horizontal load acting on the structure; it allows for better spacing of the main piles, thus reducing the variation in the load and improving the load factor. Altogether it brings about a considerable saving on the number of piles required.



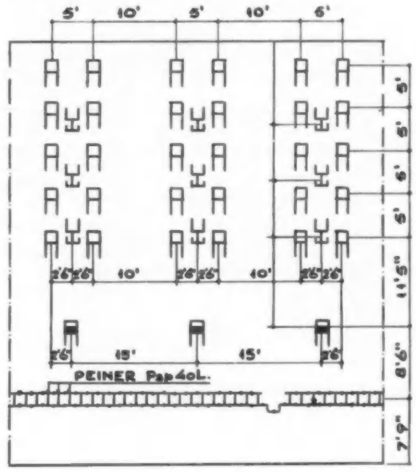


Fig. 9. Cross-section and Pile foundation plan.

carried by large ore carriers. They are worked with the aid of special unloading and loading towers, whilst the transport to and from the stockyard is effected by a conveyor belt system. Since by this method the depth of the stockyard is no longer a limiting factor (as is the case when unloading bridges are used), the quay length is no longer dependent upon the storage capacity and the berthing length can now be decisive so that a saving on quay wall cost per square meter storage space can be achieved.

The quay wall has a length of 700 m, 500 m being used for ore carriers, with a draught of 12 m. (40-ft.) and 200 m. with a depth of 9.65 m. (32-ft.)—for vessels up to 10,000 tons.

Allowing a surcharge of 30 ton per m², the total storage capacity of this site will be some 4 million tons. The maximum vertical loads caused by the bogies of the unloading towers are 240 tons. The horizontal load of the wind force on these towers is 4 ton per running meter wall. A pull of 80 tons at each bollard spaced at about 20 m. (65-ft.) centres and some water pressure behind the wall, were taken into account.

Usually such a quay wall consists of an L-shaped superstructure, supported on piles together with steel sheet piling to retain the soil. Since it was considered desirable to support directly both the front and the back bogies of the loading and unloading machines, the quaywall section finally took the shape of a U (Fig. 9).

The sheet piling placed at the front which also has a supporting function is composed of high quality steel Peine sections Psp 40L. In regard to lateral forces on the batter piles, resulting from a settling of the soil due to the load behind the wall, the piles were arranged close together in rows. Assuming a certain mutual support, it seemed justified to apply pressure piles of concrete (section 17-in. square), driven in a batter of 3:1 forwards and taking a load of 50 tons axially.

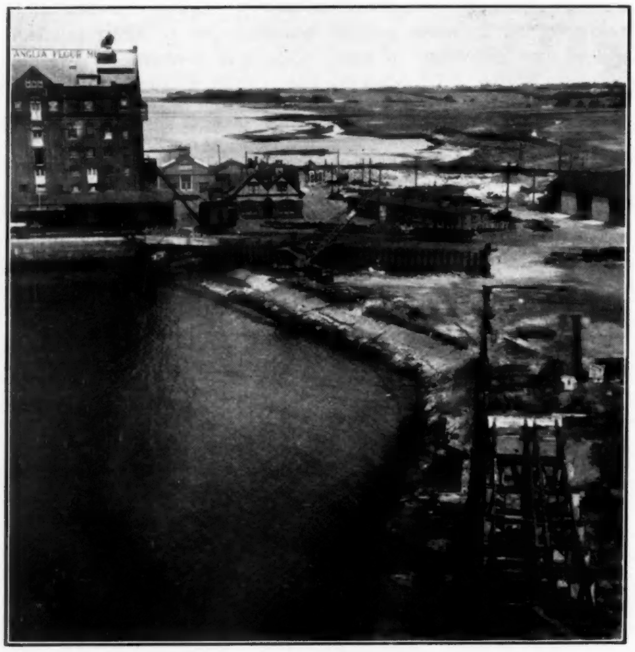
Omitting the cost of this quay wall, the capital cost of the Botlek project so far amounts to some £12,000,000. Though a considerable undertaking for the Municipality to finance (in addition to its obligations for all other kind of works), this expenditure seems modest compared with the investments to be made by the private companies, who have already spent three times as much even on the first stage of their building programme.

A Method of Joining a New Sheet Piled Extension to an Existing Concrete Quay

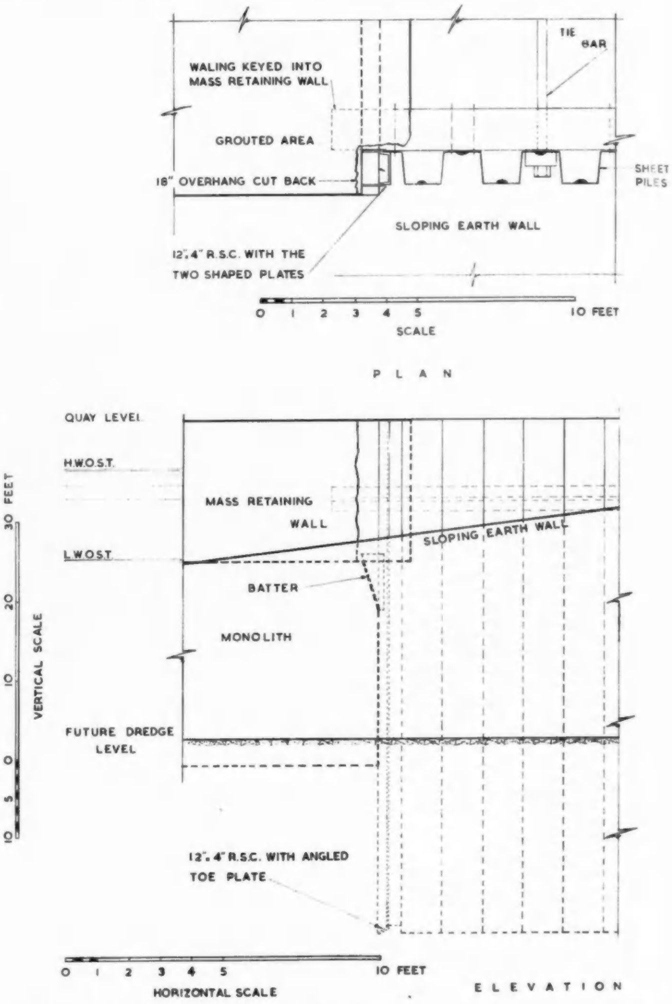
The construction of the new East Quay extension at Felixstowe Dock, described at length in the July, 1958, issue of this Journal, has now been practically completed to the design and under the supervision of the consulting engineers to the Felixtowe Dock and Railway Company, Posford, Pavry and Partners of London.

The East Quay forms a third quay in the dock and replaces an old sloping earth wall. The two existing North and South Quays, 600-ft. and 480-ft. long respectively, are of concrete construction built in about 1884. The new East Quay is of steel sheet piles tied back to a continuous reinforced concrete anchor, and has a total length of 560-ft. Work on this new quay was started in March 1959, and was carried out by the Felixstowe Dock and Railway Co., using direct labour.

The ground in the area of the new quay consisted of ballast which allowed very easy flow of water through it. Consequently it was important that where the new sheet piled quay joined with the existing quays, no fines could be leached out and thus cause settlement of these quays and the buildings close behind them.



A general view of the construction of the East Quay. The joint between the new sheet piled extension and the existing concrete quay is located below the end of the tall mill building



The joint between the new sheet piled extension and the existing quay.

In fact, a watertight joint was required. The exact nature of the ends of the existing quays was not known, but such old drawings of the dock as there were showed a series of abutting hollow concrete monoliths surmounted by a gravity retaining wall.

The joint between the new sheet pile and the existing quays was to be made as follows. Any overhang of the mass retaining wall beyond the end of the monolith had to be cut away and then the first sheet pile, with a 12-in. by 4-in. rolled steel channel welded to it, driven down with the lips of the channel against the end of the existing quay. An angled toe plate was welded to the bottom to help the rolled steel channel to " find " and cling to this face of the existing quay during driving. The space inside the rolled steel channel was then to be grouted up for a depth of 50-ft. from the quay surface to ensure a watertight joint. This work had to be done before the lower part of the sloping earth wall was removed.

An excavation was made to determine the profile of the end of the existing South Quay. It was found that the retaining wall oversailed the monolith by 18-in. and also the top 6-ft. of the monolith were battered. The 18-in. overhang of the retaining wall was cut away; the pile was fabricated and then driven. The angled toe plate kept the pile against the end of the existing quay and two shaped plates were welded on to accommodate the batter in the top 6-ft. of the monolith.

It now only remained to grout up the space contained between the channel and the end of the existing quay. It was realised that this work would require special plant and skill in operating it, beyond the capacity of the Dock Company's labour force. Competitive tenders were, therefore, sought for this work, and that of Messrs. Wimpey Central Laboratories was accepted.

It was intended to agitate the silt and existing material in the channel and then to inject Portland cement grout into this material before it finally settled. This would create a column of mixed-in-place cement mortar as a seal between the channel and the end of the existing quay. It was decided to drill down through the material to a depth of 50-ft. Then grout was injected through the hollow drill rods which were raised in stages of a foot at a time. The grout was allowed to harden off and after 48 hours the grout was redrilled to test the seal for any planes of weakness. It was found to be good and the test hole was plugged.

At the other end of the new quay the situation was slightly different and a variation in the above procedure had to be adopted.

Early in 1958, owing to the flood damage in 1953 and the sea action since, it became necessary to make an emergency repair in this corner of the dock. A special design capable of being ultimately incorporated in the new East Quay was constructed for a length of 30-ft. As described above, a rolled steel channel was welded to the first pile. When this emergency repair was done, the concrete seal inside the channel was only made for the top part of the join down to the level at which the sloping earth wall intersected the vertical joint. It was now necessary to make an investigation to discover the effectiveness of this emergency joint, and then to complete the lower part of it.

A shaft was sunk in the angle between the piles and the end of the existing quay, and at a depth of 20-ft. the lips of the channel were 1½-in. away from the end of the monolith. On further investigation it was found that this gap persisted lower down. It was decided to drill down through the temporary concrete seal on top and then into the material contained in the channel. The same procedure as above was adopted and again the seal was made successfully.

Correspondence

To The Editor of the Dock and Harbour Authority

Sir,

Timber in Dock and Harbour Engineering

In your July issue you published a letter under the above heading from Mr. E. R. A. Drew, General Manager of the Home Grown Timber Marketing Corporation Ltd. I agree entirely with your correspondent's comments and I am very glad to see that an organisation has been formed to rationalise the marketing of home grown timber in this country.

It appears to me that the most important tasks of the new Corporation will be, first of all, to educate engineers in the appropriate uses for home grown timber, their advantages and limitations and, secondly, to ensure that the industry is prepared to meet, as far as possible, the requirements of engineers in their particular needs.

If the Corporation can do this, the nation's economy is bound to benefit, as your correspondent suggests.

Yours faithfully,

J. P. M. PANNELL,
Chief Engineer.

Southampton Harbour Board,
Town Quay, Southampton.
25th August, 1960.

To The Editor of The Dock & Harbour Authority

Sir,

Mr. Newton's article—" Some recent sheds in the Port of London " (Dock and Harbour Authority, July, 1960) provides a valuable record of recent developments in the Port of London Authority's single storey transit and storage accommodation and I have no comment to offer except to point out for the record that some sheds were built before 1956 with spans greater than 65-ft. However, in your editorial dealing with the general theme of transit and storage sheds you make certain statements with which I must take issue.

The basis upon which one must make financial comparisons is the total cost of a shed (superstructure, foundations, cladding, floor, drainage, lighting, etc.) and not the cost of the main frame of the superstructure only which in general forms not more than one-third of the total cost. The figure to which you refer of of 40% additional cost of a 200-ft. space shed over one of 130-ft. span has relevance only to the main frame. The larger span produces compensating savings in the cost of foundations drainage, etc. which reduce the overall additional cost to something of the order of 5%, the exact amount depending on the particular conditions concerned. This is clearly brought out in table 4 of the article.

You ask why the loading platforms provided throughout a length of transit shed are totally unprotected from the weather. At No. 4 Berth, Royal Victoria Dock, as also at other berths, covered lorry loading platforms are provided at the ends of the shed where the roof is made sufficiently high to permit mobile cranes to work safely beneath it. The provision of cover to the rear loading platform, apart from the question of expense, raises problems connected with the working of mobile cranes on the platform. The Authority, are however, experimenting with the use of portable canopies on the rear loading platforms.

The question of providing raised loading platforms at all is the subject of much current discussion. It is probably true that where operations are 100% mechanised they are not required but, with general cargo, this degree of mechanisation is an unattainable ideal and where a considerable percentage of manual operation must persist, and, in addition, where the loading platforms are also used for railway working, raised platforms of this nature are considered to be justified.

Although it is the practice in other ports for road vehicles to enter transit sheds, this is not the case in the Authority's docks where the view is taken that transit sheds are provided for the temporary housing of goods and too much valuable covered space would be sterilised if it had to be kept clear for the passage of vehicles.

Finally, container traffic poses a number of problems one of which is the best method of handling the containers. This has not yet been resolved and no doubt will be the subject of extensive trial and error. However, it would appear axiomatic that the fewer permanent obstructions to movement and cargo disposition within the shed the better provided that economic structural designs can be evolved to achieve this end.

Yours faithfully,

N. N. B. ORDMAN,
Divisional Engineer (Plans).

Port of London Authority,
Trinity Square, London, E.C.3.
24th August, 1960.

To The Editor of the Dock and Harbour Authority

Sir,

The Operation and Administration of Ports

I am grateful to Mr. Risselada of the Municipal Port Administration of Rotterdam for having drawn attention to a statement in my Copenhagen lecture (published in your April 1960 issue) with respect to port improvement funds of the Port of Rotterdam which might be misleading or inexact.

One of the issues raised in my lecture was whether and in what circumstances it appears more advantageous to operate port terminals as public facilities, open to all vessels, or to rent them on a yearly basis to individual steamship lines or other private companies for their own exclusive use. In this connection, I mentioned Rotterdam as an example of a port where most terminals appear to have been rented.

My inference that this fact had an unfavourable effect on current revenue and consequently on accumulation of funds for major port improvement plans was based on information gathered by a small study group of very competent foreign port officials during their stay in Rotterdam in November 1958. It seemed to confirm my belief that in ports with intensive traffic the system of public terminals, in addition to its operating advantages, offers a better chance for the port administration to achieve the very desirable goal of deriving from dues on vessels and on cargo a revenue sufficient to cover current expenditure, costs of smaller improvements, accumulation of a reserve and full financial service, interests and amortisation, with respect to major port development schemes.

I am pleased to hear that the Port of Rotterdam does not appear to have any difficulties in financing port extension projects and I regret my involuntary mis-statement. No criticism whatsoever was intended from them nor from me of the Port of Rotterdam, the extraordinary efficiency of which we all admire.

Incidentally, Mr. Risselada's letter does not shed any light on the somewhat academic question whether the Port of Rotterdam would be financially better off if more terminals were operated as public facilities instead of being rented. That was precisely the point raised in my lecture and in this connection my statement about alleged shortage of funds for port improvements, if correct, would not have been " a valueless commentary on a particular form of port organisation." Obviously, I had in mind funds derived or fully amortized from current income, not from any other source.

Yours faithfully,

BOHDAN NAGORSKI.

18 Sina Street,
Athens.
16th August 1960.

Extension of Long Reach Jetty, West Thurrock

The original jetty of the Tunnel Portland Cement Co. Ltd. on the north bank of the Thames at West Thurrock was constructed in 1936 and consists of an approach running out 600-ft. from the shore and a main jetty arm of 350-ft. approximately at right angles to this, up and down stream. The new work carried out in 1958/59 consists of an extension on the same line of the approach 200-ft. out of the river, a new jetty 406-ft. long approximately parallel to the existing jetty, and two fendered dolphins extending the effective face of the new jetty by 104-ft. upstream and 110-ft. downstream.

The new jetty carries three rows of railway sidings between two crane rails. The whole track system is arranged with connections to a similar layout on the original approach and jetty.

The new approach is founded on Rendhex foundation columns and the main arm of the jetty on 43 precast reinforced concrete cylinders 8-ft. diameter on 10-ft. diameter splayed bases. In order to speed construction, a system of precast beams and slabs was employed for the deck. There was no road access at all to the existing jetty, the only connection being by means of a rail-track which handles the client's traffic and could not be used for the construction work; instead, a jetty with road access, approximately half a mile downstream of the site, was used. A 15-ton derrick was erected off this jetty founded on piles, and the jetty itself was used as a precasting yard for beams, cylinders and slabs. Materials were transported to the site of the new construction in barges.

In order to allow the client's ships continuous use of the existing jetty while the new construction was taking place, the first two cylinders are located approximately 100-ft. away from the existing jetty, the approach subsequently being closed using the Rendhex column form of construction.

Method of Construction

The method of construction was by means of a 15-ton derrick which carried out the placing of the cylinders and also handled the precast beams. This derrick was built on floats so that it could be towed into position over three prepared dolphins and sunk into place on these, from each of which it was able to cover an average of 10 cylinders. The dolphins consisted of a steel framework founded on four greenheart piles driven into the hard chalk.

The method of lowering the precast sections of the cylinders, which were 18-ft. deep and weighed approximately 15 tons, was to drive four steel staging piles round each cylinder. Supported from the heads of the staging piles were three beams carrying the jacks which were used for lowering; these were connected by means of a band fitting in a groove to the top of the first 18-ft. unit (which was bolted to the top of the splayed base). It was arranged so that this band could be removed under water without using a diver. When the bottom of the cylinder base reached the river bed, the jacks were released and a grabbing platform and tower placed on the top. The chalk inside the cylinder was then grabbed out until the cylinder had sunk to the required depth.

The main cross-head beams which span across the cylinders were cast in two halves which were placed side by side. Pockets were left to accommodate the longitudinal beams. The area between the longitudinal beams was filled with precast slabs which were provided with bars projecting from the top surface to bond in with the insitu deck slab. By this system, the only soffit shuttering required was along the outside edges of the jetty; this was supported on steel brackets temporarily cantilevered from the beams.

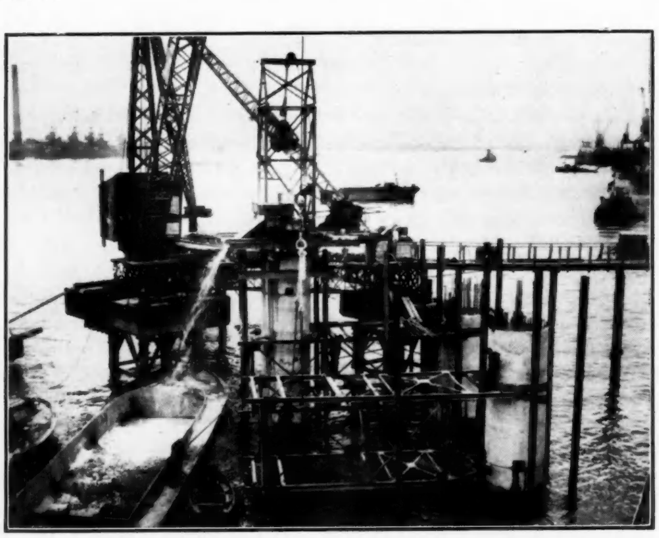
The permanent dolphins were constructed in a similar manner, on two cylinders each. They are fendered with timber, and each is connected to an end of the jetty by a reinforced concrete bridge 10-ft. wide, on intermediate supports of Rendhex columns.

Rendhex Columns

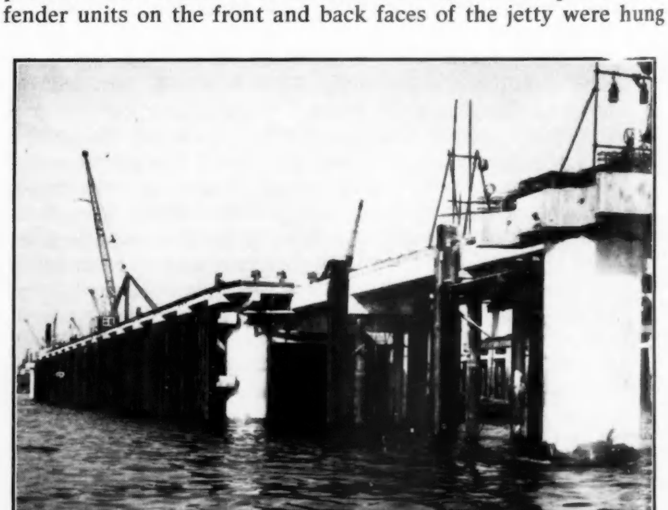
The approach is carried on Rendhex units, each cross-head beam being founded on four vertical and two raking columns. These were driven using a 4-ton single-action steam hammer, operated from a 10-ton derrick on a timber dolphin on the upstream side of the approach. Vertical piles were only "gated" at one level and could only be pitched at low water. The hammer was suspended in a cradle hung from the derrick and no difficulty was found in adjusting this to drive the raking piles. The raking piles were driven through a guiding frame consisting of two steel trusses spanning between the vertical piles.

Fendering

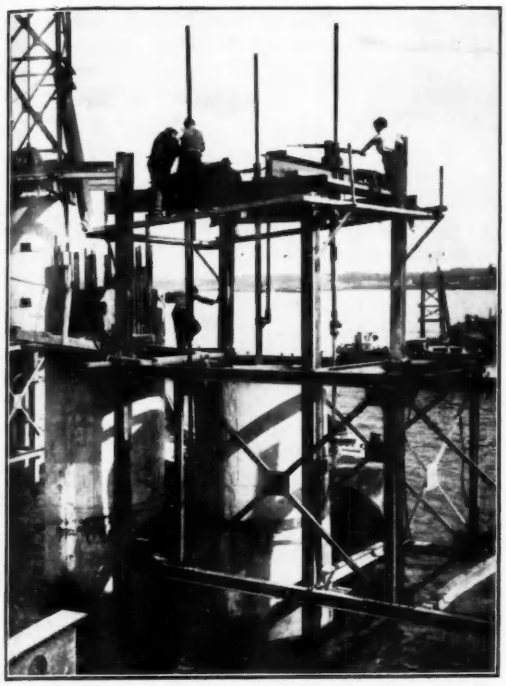
The fendering on the approach and the permanent dolphins consists of twin 14-in. square Douglas fir piles between 60 and 70-ft. long, driven with penetrations of as much as 20-ft. using a Demag D12 hammer fitted with a rope-suspended leader and provided with a helmet to fit over the heads of the piles. The fender units on the front and back faces of the jetty were hung



Early stages in construction showing cylinder being grabbed (derrick on dolphins can be seen on the left.)



Offshore view of jetty nearing completion.



Left: Lowering cylinder using screw jacks.
Above: Aerial views of old and new jetties.

from the jetty deck, one unit at each cylinder; each unit consists of three concrete saddles, jointed by four 14-in. square Douglas fir timbers vertically. The timbers are bolted to the saddles, and vertical loads are carried by M.S. hangers through the saddles. Each fender unit has four Goodyear fender rubbers (15-in. dia. on front, 12-in. dia. on back) between it and the cylinder. The depth of the concrete saddles varies between 18-in. and 3-ft. 6-in. and the weight of a complete front unit is 19 tons and the back 14 tons. Because of the weight, the complete main fender units were placed by means of a floating crane. The spaces between the fenders are filled with intermediate fenders consisting of three horizontal twin 14-in. square timbers, and two vertical 14-in. x 14-in. timbers. The horizontal timbers fit into recesses in the concrete saddles, and the whole of each intermediate fender unit was pre-fabricated and placed in position in one piece.

The consulting engineers for this contract were Sir Alexander Gibb and Partners and the main contractors J. L. Kier and Co. Ltd., and Monberg and Thorsen A/S.

Trading Conditions at Port Churchill*

In accordance with their terms of reference, the Commonwealth Shipping Committee have again examined the conditions affecting ships trading to Port Churchill.

During the 1959 season, 58 ships made commercial voyages to Churchill and loaded grain cargoes totalling 21,768.500 bushels mainly for delivery to United Kingdom and Northern European destinations. These are record figures for the port and show an increase, over 1958, of 3 ships and 1,855,500 bushels of grain shipped. The Report shows that although the port handled heavier tonnages, shipping arrivals were spread fairly evenly throughout the trading season and average turn-round times compared well with those of 1958. Delays to ships held at the Anchorage awaiting a berth worsened in 1959 however and the Report states that the additional berthage accommodation which the Canadian authorities plan to provide at Churchill is not likely to be ready for use before the 1961 season at the earliest.

The season of navigation approved by Underwriters opened on the 23rd July for ships passing Cape Chidley. The first ships to enter the Straits encountered heavy concentrations of pack ice, in traversing which one ship sustained severe ice damage and a number of others suffered minor damage. Some of the Masters who reported to the Commonwealth Shipping Committee on their experiences in navigating the route, expressed their views on how the fixed navigational aids in Hudson Bay and Strait and the aerial reconnaissance arrangements might be improved to benefit shipping. These reports have been brought to the notice of the Canadian authorities. In the 1959 season the majority of the navigation lights on the Route were changed to a type giving 10 times the intensity of earlier installations.

The Canadian authorities again operated numerous aerial reconnaissance flights throughout and beyond the season, using Churchill as the base for flights over Hudson Bay and Frobisher for flights over the Straits. The patrolling aircraft relayed information as to ice positions and weather conditions and one was instrumental in assisting the M.V. "Vingnes" when she was afire in Hudson Bay. The reports on ice and weather conditions made by the surveying aircraft were relayed to the Commonwealth Shipping Committee in London who forwarded copies to the shipping press for publication.

The season closed on the 15th October with an extension to the 20th October subject to a surcharge on the Additional Premiums. The Report states that Underwriters extended the navigation season by adding the five "surcharge" days in 1955 but, so far, no grain cargoes have been loaded out of Churchill later than the 15th October. In the light of information acquired in recent years, however, regarding the appearance of first ice along the route the Committee reiterate their opinion that, again in 1959, ships could have loaded and sailed from Churchill up to the 20th October without fear of being frozen in for the winter.

* Abstracts from "Nineteenth Report on Hudson Bay Marine Rates, 1960." H.M. Stationery Office, price 1s.

Transport of Motor Cars

New Handling and Stowing Methods

One of the papers read at the Technical Conference organised by the International Cargo Handling Co-ordination Association and held in Genoa last week, dealt with " The loading, transporting and discharging of motor cars ". New methods are being employed in these operations with, perhaps, two primary objects: (1) of making more economic use of hold space and particularly that in the lower holds, and (2) of converting the unpacked car into a rectangular cargo unit for speedier and easier handling.

The following is a summary of the new methods discussed.

(1) Alterations within the ship

a A flexible system utilising open steel flooring made up into pre-fabricated framed panels to form extra decks for the transport of cars.

b Four proposed methods of transporting motor cars on open steel extra decks formed into rectangular shaped panels which can be hoisted and stored under the lower hold decks; when these extra decks are in the lowered position the vessel can be used to carry grain in bulk.

c An arrangement of movable car decks, three units operating on both the port and starboard sides of the lower hold.

d An arrangement for a pivoting car deck which could be operated in conjunction with the carriage of bulk ore.

e A system which incorporates the use of laminated wooden beams placed athwartships, covered with portable wooden decking sheets which will provide either one or two additional decks. The beams are fitted to a metal framework and this can be removed when not required. For the carriage of grain cargoes it is necessary only to remove the decking sheets; the semi-permanent beams and framework would not, it is claimed, interfere with the loading or discharge of grain or the erection of shifting boards.

f The Carron side-transporter system of loading cars as incorporated in the P. & O. SN. Company's new liner " Canberra ". The simple principle is that of a retractable boom operating over a span of 90-ft., plumbing, by means of a transverse carriage, both the centre line of the ship and the quay alongside. The transverse carriage incorporates a car platform and thus provides access to each of the decks in the lower hold.

g The imposition of false decks, made of 9-in. x 2-in. timber laid fore and aft on a structure of tubular scaffolding. The stowage space thus made available is divided up into bays each having a clearance of 6-ft. 4-in. into which a car can be wheeled and lashed to the alongside uprights. The structure can be quickly dismantled and stowed away for the return voyage.

It is worth noting that more than one of the above adaptations of the lower hold space has been evolved with an eye to the return voyage. Whilst certain inventions had adequately met the need for shipping the maximum number of cars outwards from Europe to United States ports, (to take the main traffic now being considered), the economic use of the ship for the return voyage insists on being recognised. It is interesting that bulk grain has been mentioned as being a commodity that could be stowed and discharged without, in certain cases, interfering with the false deck structure. Whilst some sweeping and trimming would be necessary in such cases, it is a fact that few bulk commodities are more co-operative in self-trimming than Canadian and American grain.

(2) Converting unpacked cars into rectangular cargo units

h The open crate. A tubular steel erection which it is claimed can, according to the size of the cars carried, be erected to give up to five skeleton decks in a lower hold. Alternatively, cars can be carried two-high on deck. It is claimed for tubular scaffolding when used to form additional decks that:
1. it is sufficiently flexible to " give " with the movement of the ship at sea,
2. it takes up little room on a return voyage,
3. it commands a ready sale value at the port of discharge, if it is not considered economic to return the equipment.

i A wooden open sided car crate which it is claimed, can be used above or below general cargo. The crate can be assembled, the makers claim, in less than four minutes and the car run out in less than a minute. The crate is built in seven sections (the roof is in two sections); the external measurements are 15-ft. 6-in. long 7-ft. wide and 6-ft. high. When collapsed, the case measures 1-ft. 8-in. high.

j Collapsible wooden crates that can be supplied to shipping companies who seek an alternative to structural alterations to their vessels. These crates can be assembled on the quayside without skilled labour. The completed crate is sufficiently strong to permit three-high stowage (which is high enough to fill the normal lower hold) of the cars. It is a fact that, given adequate pre-stowage arrangements as between the suppliers, the shipping company and the port authority, a very large number of cars can be supplied (and discharged) in a minimum time.

k Two collapsible car crates, using steel tubing and timber which has been tested to support a five-ton load. When collapsed the crate parts can be piled to a height of about 15 cm. Apart from the fact that the roof is attached with hinges to one of the crate sides, four cradles are incorporated within the roof and in these, it is intended, the wheels of an unpacked car placed on top can lie and the car thereby be secured.

There are of course specialised types of car crates which cater for the constant flow of certain makes of car. For most types of car crates it can be claimed that:

a They can be handled by forklift trucks, both on the quay and within the ship's holds.

b The space occupied in return voyages is kept to a minimum and general cargo can be piled above the collapsed crates.

c They tend to become increasingly simple both in putting together and in dismantling.

d Complete protection to the car is offered in some cases by the use of detachable plastic lining to the crate.

Bulk Handling Facilities at Portland, Oregon

In order to satisfy the increasing demands of manufacturers who depend on the Port for their supplies of imported ore and ore concentrates, the Commission of Public Docks in Portland approved in 1954 a programme of modernisation and new construction. During the past six years a 3-berth general cargo terminal has been built at Pier 1, three further general cargo berths have been modernised at Pier 2 and work on a bulk handling berth at Pier 4 will be completed by the end of this year. This will provide 1,140-ft. of berthing space and will be equipped with a 900-ton per hour unloading tower, and three railway sidings designed to accommodate more than 70 trucks each. Thirteen miles of piling, some 120-ft. in length, have been used to support the main concrete pier and a barge basin is also to be provided equipped with a conveyor belt for direct transfer of the ore from ship to barge. A crane will feed the ore on to the belt which will run along the inside of the berth.

Pier 4 is directly opposite the port's other bulk handling pier, No. 5, which has a 350-ton per hour unloading tower.

Hydraulics Research at Wallingford

Abstracts from Report for 1959*

As in previous years, this report contains separate accounts, in greater or less detail, of the principal investigations carried out by the Hydraulics Research Station in the year under review. The work has ranged widely over the field of civil engineering hydraulics and has included both studies of specific problems and background or fundamental research.

The Station is being enlarged to accommodate an expanding programme of research and the extension of the Main Hall is well advanced and should be ready for occupation in the autumn of 1960. This extension measures 300-ft. x 100-ft. and will house a large wave basin 270-ft. in length, the greater part of which will be devoted to background research on coastal erosion. A small portion of the basin is being reserved for investigations of wave disturbance in harbours and allied problems.

The report of the Director describes an interesting technique for measuring littoral drift by means of fluorescent tracers. A knowledge of this rate of drift is of importance to the coastal engineer, but hitherto no generally satisfactory methods have been available for determining it. The technique employs a tracer material (Rhodamine B), which glows under ultra violet light, incorporated in artificial pebbles or sand grains.

By measuring periodically the spread of the tracer material along a beach the rate of drift can be calculated. With a pebble beach, the tracer pebbles are counted at night under ultra violet light. With a sand beach, samples are taken and the concentration of tracer particles determined. The calculated drift will be compared at the end of a year with the actual drift at Rye, since here shingle drifts towards the western breakwater of the River Rother and piles against it; the actual quantity of drift can be measured by finding the rate at which shingle would have to be removed from the breakwater to maintain a constant beach line. The results obtained so far are promising.

Similar experiments are being made on shingle beaches at Deal and Dungeness, and preliminary experiments have begun on a sand beach at Dawlish Warren in Devon.

Hydraulic Structures

Avonmouth Fire-boom

A floating boom is used at the entrance to the oil basin at Avonmouth docks to prevent the spread of oil and reduce the risk of fire. This oil basin is to be extended and a new fire-boom will be required. A design has been proposed consisting of three sections, each 90-ft. long, hinged together; opening would be carried out by folding each section in turn back to its neighbour. In the final stage of the opening, the three sections, locked together, would turn about the landward hinge to contact the dock wall. The motive power is to be provided by water jets supplied from pumps housed on the boom and tests of each stage of opening have been made on a 1/15 model to determine the time required to open the boom with pumps of different capacity. The mass distribution in the model was adjusted to give the scaled radius of gyration so that accelerations were properly reproduced.

Moments were applied about the hinge to take account of the wind forces acting on the structure. It was found that the non-stop opening time (i.e. disregarding the time needed for braking) was inversely proportional to the square root of the effective moment (moment from jet-wind moment) on the boom, and a thrust parameter was derived which enables the non-stop opening times to be scaled to full scale. The tests showed, however, that to reduce the operating times substantially it was necessary that the jets could be reversed during opening so as to act as a brake. Scaling parameters were also derived from the tests to allow the braking times and distances to be estimated.

Queen Elizabeth II Dock (Fig. 1).

The Station is investigating the causes of silting in the new Queen Elizabeth II Dock for ocean-going tankers. A short field investigation has been completed and work is at present being carried out on a 1/60 scale model. The dock is on the south side of the Mersey estuary to which it is connected by a lock designed to accommodate vessels 650-ft. in length. The lock is equipped with sliding cassion gates which prevent run-in at

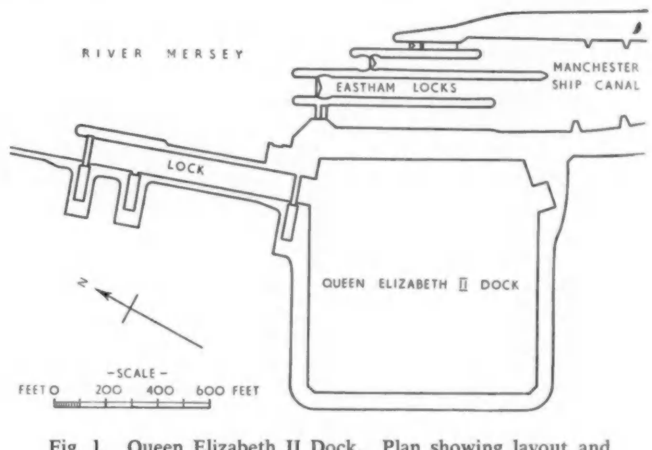


Fig. 1. Queen Elizabeth II Dock. Plan showing layout and position in relation to Manchester Ship Canal.

high spring tides. The rate of siltation in the dock varies between 3,000 and 8,000 cubic yards per week, and the problem is aggravated by the difficulties involved in using dredgers in an oil dock.

Water levels in the dock and in the canal are maintained at a level slightly higher than high water of average spring tides. The canal is supplied largely by fresh water tributaries but also to some extent by run-in through the Eastham lock at high spring tides; its water is therefore saline but less so than that of the estuary. The level in the dock is maintained by the frequent use of balancing culverts which supply water from the canal. The dock water too is, therefore, less saline than that of the estuary.

The dredged material, which is almost wholly in the silt range, can only enter the dock in two ways; from the canal through the balancing culverts, or through the navigation lock. Analysis of samples taken from the balancing culverts showed that a negligible quantity of silt entered from the canal. It was, therefore, clear that by far the greater part of the silt must enter through the lock.

Conditions in the estuary immediately outside the lock are favourable to the almost continuous settlement of silt from suspension. A clearly defined layer of unconsolidated silt or mud, with very high concentrations of solids, has frequently been

* Hydraulics Research 1959. Report of the Hydraulics Research Board. Published for the D.S.I.R. by H.M. Stationery Office. Price 5s. 6d., by post 5s. 11d., U.S.A. 99 cents

observed outside the entrance. This layer is quite mobile, and as bed levels in the area are slightly higher than those in the lock, the mud layer could gravitate—as a turbidity current—into the lock when the outer gate is opened. It appears, however, that an effect of greater importance is the salinity or density difference between the estuary and dock during a normal locking operation. Such operations take place at or near the time of H.W. when the differences in salinity are at a maximum. The following description of what is believed to take place is based on measurements in the prototype, subsequently corroborated and extended by observations in the model.

As the outer lock gate is opened an inflow of the more saline and denser estuary water takes place near the bed, carrying a large quantity of mud (in high concentration) into the lock; and there is a corresponding surface outflow of less saline and relatively clear water from lock to estuary. One result of this process is a significant increase in the mean salinity of the water in the lock. After closing the outer gate, the lock water level is raised by the normal transfer of water from dock to lock through sluices. The sluice outlets are situated near the bottom of the lock and the high velocity jets produce extensive mixing in the lock. At this stage the salinity of the lock water has been reduced slightly but is nevertheless appreciably in excess of that in the dock.

When the inner (lock/dock) gate is opened the first stage is repeated, the silt being carried into the dock by the strongly inflowing density current near the bed. The passage of ships laden or light, in either direction complicates the process just described and is in fact one of the main objects for study in the model. It has been found however, that the effect of shipping does not fundamentally alter the action of the density currents, but merely modifies it. For example, the model has demonstrated that the inflowing density current near the bed is not reversed or annulled by the passage of a lightly-laden ship from the lock into the dock.

The intrusion of the salt water wedge, ample evidence of which was obtained by prototype observations, was reproduced very satisfactorily in the model using a salinity scale of 1 : 1, and a number of schemes for the reduction of siltation have been tested. The most satisfactory solution would be to impound the dock with relatively clear water from the estuary at or around the time of high water. This would increase the salinity in the dock, but would entail the very expensive installation of large pumps. The most promising compromise appeared to lie in the use of vertical jets or of turbulent uprising currents immediately outside the outer gate. These would be brought into action some time before the gates were opened, so that an appreciable proportion of the mud lying in high concentrations near the bed would be carried in suspension in the upper layers and would, therefore, be transported away from the lock by the outward-flowing surface current when the gates were opened.

Model tests on the use of vertical water jets showed that the rate of siltation could be reduced by up to 60 per cent, but that the head and discharge requirements of the pumps would be excessive. The use of a screen of air bubbles has also been studied; the first experiments showed this to be nearly as effective as the water jets but further work on it is required before its efficiency can be assessed.

Other investigations include Avonmouth Docks where the Port of Bristol Authority have asked for a study to be made of means of reducing silting and a model is being constructed. Under the Colombo Plan a member of the Station staff visited Bombay to advise and assist the Bombay Port Trust in the use of radioactive tracers for determining silt movements in the harbour. A team from the Station is now carrying out an investigation of Karachi Harbour for the Government of Pakistan. There are several investigations in hand concerned with projects in New Zealand.

Estuaries

The Thames Estuary

The investigations carried out during the year by the Port of London Authority with the advice and direction of the Hydraulics Research Station included the following:—

(a) At present the larger vessels using Tilbury Docks can only use the Western Entrance Lock on the flood tide, velocities past the entrance on the ebb tide being as high as 6 ft/sec. An investigation is being made into ways and means of improving navigational conditions at this entrance so that it could be used on an ebb tide by vessels up to about 500-ft. in length.

A large undistorted model has been built to a scale of 1/150 at No. 8 Shed, Royal Victoria Docks, representing about 5½ miles of the estuary from the lower end of Long Reach to a point in Gravesend Reach just downstream of Tilbury Basin. By circulating water from one end of the model to the other it is possible to reproduce the correct flood or ebb current velocities at fixed tide levels.

Several schemes of lead-in jetties involving the alteration and extension of the existing structures have already been tested in the model with some success. In addition to observing the navigational protection afforded by each scheme and the changes in flow pattern which would take place, experiments are being conducted with a radio-controlled model ship which represents one of the vessels of the required size at present using the Tilbury Docks. The forces on the jetties when the vessel is lying alongside are also being measured.

At present the impounded water in Tilbury Docks is drawn from the Tidal Basin. The water in the Basin is highly silt-laden and an alternative site for the intake is under consideration. Three such sites have been considered, and a short field investigation was carried out by a survey team from the Station in order to advise the Port of London Authority on the best site for such an intake. The survey team also collected information on current velocities at a number of stations to check the performance of the 1/150 model.

(b) There are several sites in lower Thames where considerable areas of the bed are dry at low water, and which might provide opportunities for reclamation and river training.

Reclamation of this nature has the effect of reducing the tidal capacity and hence the tidal discharge to some extent, and this in turn might lead to some deterioration in depths. In addition local accretion or erosion might be brought about with resulting lateral movements of the navigational channels. Experiments were therefore carried out in the 1/600; 1/120 model of the Thames Estuary to study the effects of the reclamations on the regime of the estuary. Each area was considered in turn and the effect on tide curves, current velocities and flow patterns was observed.

It was concluded that reclamation at two of the sites would have no significant effects on the estuary but the experiments suggested a better alignment for the reclamation wall at one of them. Reclamation at the third site to the extent investigated in the model would cause significant changes in the general flow pattern in the western half of Sea Reach, and probably cause changes in a channel which at the present time is fairly stable and requires little dredging. Such changes would not necessarily be adverse, but a more detailed investigation of the problem in a large model which could reproduce the effect of wave action in Sea Reach would be desirable if a definite proposal to reclaim this site were put forward.

The Mersey Estuary

Experiments have continued on the two tidal models built for investigation of the Mersey estuary—a 1/3,200 : 1/120 model of Liverpool Bay, and a 1/550 : 1/60 mobile-bed model of the upper estuary and the field work was completed during the year. Both

field observations and model experiments have shown that sand and silt are transported up-river from the mouth of the estuary, mainly by means of density currents which produce a net landward drift of water near the bed.

A detailed survey of current velocities and directions, moulded to the 1911 survey, was undertaken in the Liverpool Bay model to obtain a picture of the general circulation in the Bay before the extensive training of the main shipping channel was carried out. Subsequently, the model was remoulded to the 1957 survey and similar observations, which are at present being analysed, were made. Field observations of currents and suspended load at a number of stations in Liverpool Bay were completed during the summer of 1958.

Further information on the movement of material in the Bay was obtained from an experiment with radioactive tracers carried out in the area where large quantities of dock silt and a proportion of the material dredged at Bromborough Bar are deposited. Scandium 46 (half life 84 days) incorporated in boron-free glass was chosen as the tracer element. 200 grams of active tracer material were injected on the bed at the time of high water of a neap tide at a position 3,500-ft. S. by E. of the deposit buoy. The tracer moved quite freely and indicated that material dumped in this area was not likely to remain there for long. With tides increasing to springs the movement became more pronounced, with long tongues developing in both the flood and ebb directions, the predominant movement being in the flood direction. The results of this experiment, together with the observations of current velocities and suspended load, are still being analysed.

Experimental work in the model of the upper estuary has been mainly concerned with a study of siltation on both the Garston and Eastham channel bars. A detailed survey of current velocities carried out in the model showed that the Middle Deep is a flood channel, the drifts at all depths being landward; and that the Eastham and Garston channels have ebb characteristics, the drifts at all depths being seaward. In the Eastham and Garston channels, the upstream limits of the density drift of bed water were found to be just off Bromborough Dock entrance and downstream of Dingle jetty in the Pluckington Bank area respectively, i.e. in the zones where heavy siltation is known to occur.

The important inter-relationship that exists between these three channels was clearly demonstrated by an experiment carried out in the model using fluorescent tracers. The individual grains of a typical sample of sand from the bed of the model were coated with a fluorescent dye and "Aerolite" glue. Having been deposited in four small piles in the Narrows, the movements of the grains were detected by means of an ultra-violet lamp. The grains passed along the bed of the Narrows, up the Middle Deep and then down the Garston and Eastham channels.

Other model experiments and field observations have confirmed that accretion on Bromborough Bar takes place during the ebb tide when the water flowing down the Eastham channel decelerates on reaching the area of slower-moving, deeper water just downstream of the bar, with a consequent settlement of some of the sediment load. In these experiments bed material was continuously injected in the Narrows; the major part of it first moved upstream and siltation subsequently took place on Bromborough Bar, mainly by the deposition of material which first travelled up the Middle Deep and then down the Eastham channel to settle out during the ebb tide.

The Karnafuli River (Fig. 2)

As a result of the partition of the Indian sub-continent in 1947, the Port of Chittagong with only four berths having a total frontage of 2,300-ft. and an annual working capacity of ½ million tons, had suddenly to cope with the requirements of virtually the whole of E. Pakistan, a country with an area of 54,000 square miles and a population of 42 million. By building additional berths and providing modern dockside facilities, the total tonnage handled was trebled by 1954 but the future growth of the Port was then seriously threatened by insufficient depths at, and in the approaches to, the jetties. Very little river training or dredging had been carried out either during the war or for some years afterwards, and by 1954 eight of the thirteen jetties had 18-ft. or less of water at Indian Springs Low Water (I.S.L.W.). In addition, the low water channels upstream of the jetties were very unstable and it was feared that movements of these channels might lead to further deterioration of the navigable channels downstream. The Hydraulics Research Station was asked to study conditions in the estuary and to investigate ways of improving navigation conditions there; the work is being carried out under the auspices of the Colombo Plan.

Experiments are being made on a 1/500 : 1/60 movable bed tidal model of the estuary and very detailed information on the prototype is being compiled and analysed. Brief references to the investigation have been made in previous reports, and it has now reached a stage which permits a somewhat fuller report to be given.

Before the effects of any training works could be studied in the model, it was necessary to ascertain the accuracy with which past known prototype behaviour could be simulated in it. This "proving" stage of the investigation involved many experiments and adjustments but, as a result of it, satisfactory model/prototype conformity was established in respect of tidal reproduction and propagation, float tracking, velocity distribution and the movements of channels and the resulting silting. When the model was remoulded to the 1958-59 dry-season river survey and conditions had stabilised, simultaneous tidal observations were made at points corresponding to gauges near the jetties (Sadar-

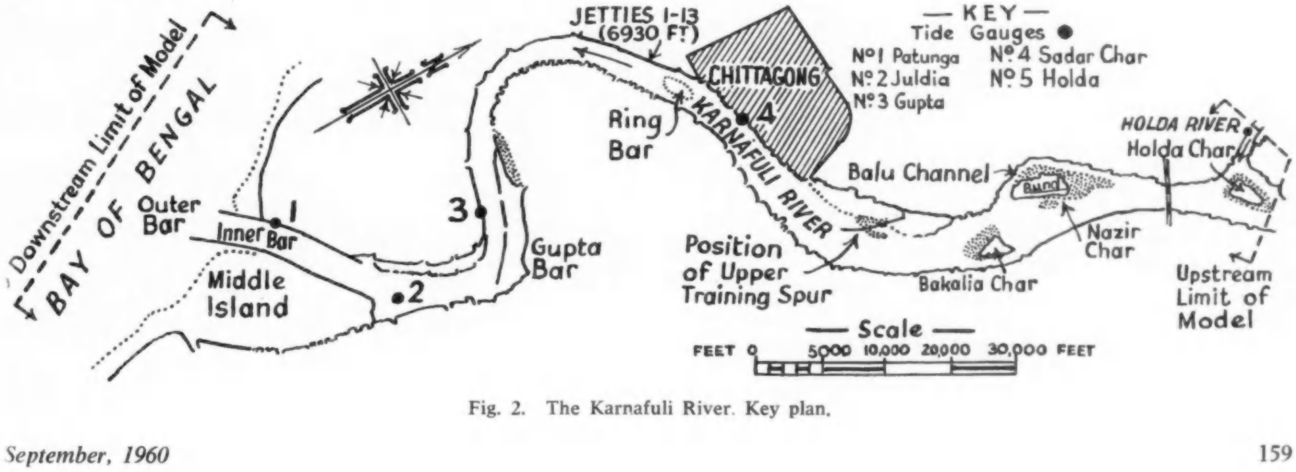


Fig. 2. The Karnafuli River. Key plan.

ghat) and some 10 miles upstream (Halda); these showed that tidal penetration had markedly improved since 1954, the year in which similar observations were last recorded on the river. The Port Authorities were accordingly asked to repeat tidal observations at Sadarghat and Halda during February 1959; the results obtained were found to be in close argreement with the model predictions.

Training Works

During the course of the investigation the following works have been carried out by the Port Authorities acting solely upon the advice of the Station and Sir Claude Inglis, who has been retained as Consultant for this project. The advice given was based on both model experiments and studies of prototype data:

(a) removal of the Ring Bar by dredging. This bar, situated in mid-stream immediately above the jetties, caused bifurcation of flow and the re-opening of a secondary channel opposite the jetties;

(b) closure of the right-bank Balu Channel by a T-head bund of overall length 5,800-ft. This has constrained the river to two channels instead of the previous three in the unstable region about 5 miles upstream of the jetties. It will prevent the repetition of an unfavourable meander cycle and will permit the future reclamation of an extensive tract of rich alluvium;

(c) cessation of spoil dumping opposite the jetties;

(d) dismantling of the 4,600-ft. long Upper Training Spur. This spur was constructed during the war as an emergency measure to arrest erosion of the Chittagong foreshore, but it was poorly aligned and positioned:

(e) modifications to the river entrance training works;

(f) dredging on the Outer Bar. This was necessary due to the growth of a shoal which had always existed on the south side of the river entrance; the required depth on all leading lines over the Outer Bar was successfully restored by dredging;

(g) re-positioning of the offshore dumping site. As the Port does not possess the necessary equipment for dumping spoil above H.W. springs, a site was selected seaward of the 5-fathom contour, more than a mile offshore and approximately two miles westward of the river entrance. It was also recommended that, if possible, dumping be carried out during the flood tide.

All these works have been carried out since 1954 and since that time there has been a marked progressive improvement of conditions at and near the jetties; a comparison of all the available surveys shows that conditions in the Jetty Channel are better now than at any time before. The present uniform width and depth of the navigable channel at the jetties and in the approaches to them is considered very satisfactory by the Chittagong Port Authorities; the port has broken all previous records by handling 2,258,397 tons during the period 1958/1959.

The study in the model of various training works suggested by the behaviour of the model has almost been completed. The works have been planned with the object of stabilizing the river —maintaining and, if possible, still further improving the very favourable present-day conditions. Due to the non-availability of boulders and the very high cost of importing them, the more conventional forms of training cannot be adopted; the required training has therefore to be accomplished with short bunds combined with carefully planned dredging.

In addition to the model experimental work, the following studies have been completed or are nearing completion:

(a) the effects of the closing of the dam now being built at Kaptai;

(b) a history of the lower river from 1840 to 1959;

(c) an assessment of the effects of existing training walls upon the regime of the river and the depths at crossings;

(d) a comparison of depths at the jetties to determine a relationship between silting there, the intensity of freshets and channel alignments upstream;

(e) the volumetric analyses and comparison of sections within the jetty reach and at the bars to determine the factor affecting deterioration of depths;

(f) the preparation and comparison of erosion/accretion diagrams to study the outfall area and the effects of freshets river entrance training works and littoral drift.

The Tees Estuary

An investigation of the Tees Estuary has been undertaken to study problems associated with the formation and maintenance of a dredged shipping channel in the approaches to the estuary; other questions to be investigated are concerned with the effects of reclamation works inside the estuary on depths in the shipping channel.

A 1/200 : 1/60 mobile-bed model of the mouth of the estuary and the adjacent beaches has been built in one of the large wave basins at the Station. This model reproduces the waves, the tidal flow and the complex currents caused by the interaction of tidal currents in the North Sea with those in the estuary. The model is now operating and the effects of various proposals designed to increase the depths across the bar are being studied.

Before starting work on the model the Station's Survey Team, measured and recorded tidal currents in the prototype, and an analysis of the wave conditions at the mouth of the estuary was carried out with the aid of data supplied by the Meteorological Office. In addition, the Tees Conservancy Commission carried out some special test dredging to provide information on the rate of silting in the entrance channel. This preliminary work has been of great value in proving the model.

Portsmouth Harbour

The model investigation of Portsmouth Harbour was completed during the year. Tests showed that current velocities in the navigation channels and in the areas where bed movement is important would, in general, be reduced by up to 25 per cent if proposed reclamations were carried out. However, as the mudbanks and dredged areas within the harbour are very stable, and the amount of material carried in suspension was found to be small, a reduction in velocities should not result in a significant increase in siltation in the harbour or in the erosion of material from the mudbanks.

Hong Kong Harbour

Extensive land reclamation has taken place in Hong Kong Harbour during the past fifty years and further large-scale schemes are planned. There is some evidence that this reclamation has resulted in increases in the velocities of tidal streams and fears have been expressed that further reclamation would result in higher stream velocities and thus create navigation problems. The Hydraulics Research Station was asked to investigate the effects of such schemes and is doing so with the aid of a tidal model.

The harbour lies between Hong Kong Island and the mainland (Fig. 3) and is open to the sea at each end. A tide generator had therefore to be provided at each end of the model, both generators being of the controlled-weir type. Tidal differences in level at the ends of the harbour are small, amounting to a maximum of about 6 inches in the prototype (0.1 inches on the model), so that a high degree of accuracy in the generation of the tides was necessary.

Originally, it had been planned to carry out experiments to ascertain for the harbour as a whole, firstly whether any increases

in the strengths of the tidal streams had been caused by the reclamations completed between 1903 and 1957, secondly what changes had resulted from the construction of the airport runway (which projects some 7,000-ft into Kowloon Bay), and finally the effects of further reclamations which might be carried out in the future. Before the experiments could be started, however, certain urgent localised problems had arisen concerning particular reclamations and their possible effects on tidal streams in their immediate vicinity.

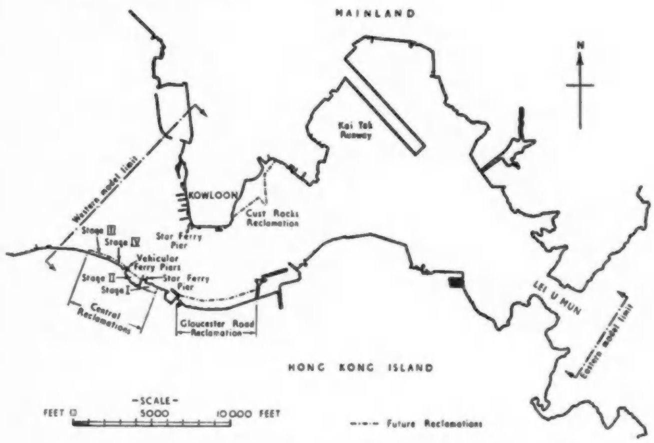


Fig. 3. Hong Kong Harbour. Key plan showing proposed future reclamations.

These problems were therefore investigated on the model as soon as the proving had been completed and for this purpose the model has been operated under continuous flow conditions representative of maximum velocities on the flood or ebb tides.

Waves and Sea Defences

Port of Burnie

A short reference was made to this 1/100 wave disturbance model in last year's Report; the investigation has now been completed, although it has taken a slightly different form to that envisaged last year. The Marine Board of Burnie, for whom the investigation was undertaken, plan to increase the capacity of the port, and they required information on the relative merits of various schemes that had been proposed. The main purpose of the investigation was to determine the minimum length of breakwater and its best alignment consistent with navigational needs, to give the required protection to shipping. The experiments involved some twenty-seven variations in layout which could be divided into three possible development programmes, (See Fig. 4). The programmes are:

(1) Extension Development.
(2) Island Development—two alternative alignments.
(3) Link-up Development.

In addition, four subsidiary investigations were made: these were concerned with (a) the effect on the heights of residual waves of four different structural designs of a pier; (b) a wave-induced current; (c) the effects of possible future reclamation; (d) the horizontal movement of a tanker.

It is planned to build additional berths in stages, either as a New Pier to the south of Jones Pier, the latter eventually being demolished, and/or wharfs to the north of Ocean Wharf. The initial standard of protection required was such that the residual wave-heights at these and the existing berths were to be about 25 per cent of the height experienced at sea in the approaches to the port; the ultimate standard was to be 10 per cent.

Information sent by the Marine Board showed that waves approaching from about 060° were the worst experienced in the port and that the 9-6 sec. band of wave periods was the most frequent; the majority of the experiments were therefore made with such waves reproduced in the model, although other waves were also considered. In general, the method used was to measure the residual wave-heights alongside a berth in the model for different periods and directions of approach of waves, and to compare those heights with the heights of the waves outside the harbour. From these comparisons response curves for different positions were plotted.

The subsidiary investigations were not of a detailed nature but were aimed only at obtaining an indication of conditions likely to be experienced in the prototype. The results obtained were as follows:

(a) Structural design of the new pier: as the form of construction of the pier will have an effect on the movement of berthed ships, a number of possible designs were tested. Two of these—an open pier supported on piles and a pier constructed of fill finishing on a battered slope fronted by a wharf apron of piles—were found to be preferable to the others.

(b) Wave-induced currents: a clockwise current was found to exist in the S.W. corner of Emu Bay; it impinged upon the south side of Jones Pier or the New Pier and was very marked with waves approaching from 060°. There is evidence of the existence of this current in the prototype: it is apparently caused by the building up of a head of water near the shoreline where the waves are steep and breaking.

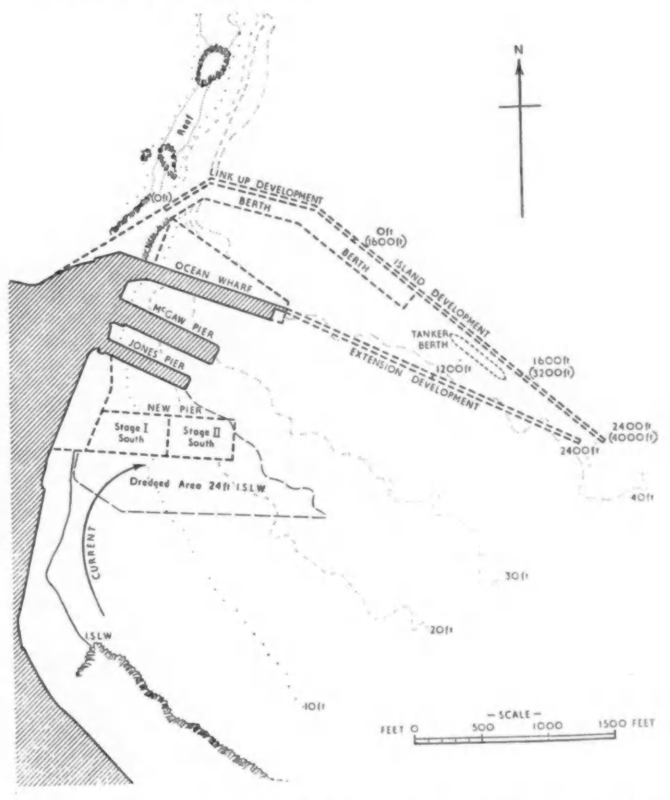


Fig. 4 Port of Burnie. Plan showing proposed development schemes.

In the existing harbour, this current has no detrimental effect upon the operation of the port, but if at a later date it is thought desirable to divert its flow clear of the New Pier, the tests indicated that this could be achieved by building a groyne out from the shore.

(c) Future reclamation: if the foreshore to the south and west of the New Pier were to be reclaimed, there would be a loss of

" spending-beach " area, and wave reflections off the bund of the reclamation might cause increases in residual wave-heights in the harbour. Such reclamations were therefore reproduced in the model; the results showed slight increases in the residual wave-heights.

(d) Tanker berth: if the Island Development scheme is adopted, it may incorporate a tanker berth situated within the eastern 1,000-ft. of the breakwater. The disturbance at this berth in terms of the movement of a tanker was assessed by means of tests on a 1/100 scale model of a T2 Tanker (16 500 tons d.w.). The conditions at the berth were found to be remarkably quiet, the horizontal motion of the unrestrained tanker being less than 11 inches in prototype terms, regardless of the period of the wave and its direction. A vessel moored by ropes would move rather more, the increase depending upon the elasticity of the fenders and ropes. For normal mooring systems the movement would be expected to be two or three times as great as the unrestrained movement.

Ship-Ranging Experiments

Further experiments have been made in connection with the study of the movements of moored ships subjected to long period waves. The model ship used in the experiments was 80 in. long and weighed 135 lb; it was moored symmetrically, with the mooring lines along the longitudinal axis of ship, in the stationary wave flume previously described. Part of the investigation was devoted to separating the effects of non-linearity and of free travel on the mooring extension law (free travel meant that the ship could move appreciable distances with the moorings untensioned). Several conclusions have been drawn from these tests: notably, that in the absence of free travel, a ship with a non-linear type of mooring will always respond to wave action with a regular oscillation of the same period as the exciting waves, although at certain wave amplitudes and periods, alternative motions are possible also. If free travel is possible, however, any type of mooring can result in non-repeating motions, or motions whose period differs from the period of the exciting wave.

Turning to the prediction of mooring forces, if the ship motion is assumed to be simple harmonic with the same period as that of the exciting wave, and the mooring is assumed to have a power extension law of known constant and index, then the basic differential equation yields a simple relation between the motion of water particles at the node and the movement of the ship. An effective method of plotting this relation has been found and, with this presentation, a large number of experimental results with different free travels and mooring characteristics have been compared with the elementary theory. The agreement was found to be close.

As prototype ship mooring lines have a load extension curve which may be fitted fairly closely to a power law, even when free travel occurs, it follows that mooring forces may be estimated for symmetrical longitudinal moorings, given the characteristics of the waves and restraints. Thus, this analysis may reasonably be applied to full scale mooring problems where the direction of wave motion is parallel to the quay—that is, when the impacts of the ship with the quayside are not a major factor. The analysis does not deal with the case of wave motion perpendicular to the quay where ship impacts are the major problem, due to the large differences in stiffnesses of mooring ropes and fenders rendering the mooring system distinctly asymmetrical.

Legislation in the Port Industry

Safety in Harbour

By LAURENCE WEBLEY, LL.B.

The previous article on this subject* outlined the law relating to the construction of a port. When a port is in operation it must be used and administered with due regard to safety. This is the responsibility of the authority in charge within the limits of the port. In respect of such matters as the buoying of the harbour, the erection and alteration of lighthouses, beacons and sea marks and similar aids to navigation, the authority must obtain the permission and follow the directions of Trinity House.

When the harbour in question is a natural one there is, in fact, no legal obligation to mark the navigable channel. If, however, the channel is marked the authority must take reasonable measures to see the buoys are kept in position. The extent of the obligations of a buoyage and beaconage authority was defined in a case decided in 1938, "the Neptun ". The judge, assisted by the Elder Brethren sitting with him in court, defined the obligations under seven heads:

1. That the authority should take soundings and find the best navigable channel in the river.
2. That having found the channel the authority should place sea marks, i.e. lightships, buoys, floats, in positions of the best advantage to navigation.
3. That such seamarks should carry adequate lights by night to enable the channel to be easily found and properly kept by vessels.
4. That the authority should have the channel resounded as opportunity offered.
5. That the authority should keep a vigilant watch on changes in the river bed and have the seamarks altered, moved or renewed as required.
6. That records of the changes in the soundings and of the changes made in the seamarks should be maintained and preserved for the guidance of subsequent officials in the authority.
7. That there should be conspicuous publication of any such further information as might supplement the guidance afforded by the sea marks.

The case in which these obligations were laid down concerned the Humber and the judge added they could be considered the minimum duties in respect of such a great and busy highway.

A harbour authority is required to provide a lifeboat and life saving rocket apparatus of a type approved by the Board of Trade. Competent people must be made available to man the boat and the apparatus. Certain recording instruments and weather records must be maintained. The former consist of a self registering tide gauge and a barometer. A return of their readings and of a daily record of wind and weather conditions must be sent to the Board of Trade every month.

As to safety in the harbour generally, fire was especially feared in the days of wooden ships and it is not surprising that the old Acts lay great stress on this danger. Some of their provisions, which are still in force, have a rather old fashioned ring save perhaps in relation to yachting harbours. The boiling and heating of tar, pitch, resin, turpentine and so forth requires the harbour authority's sanction; it is provided that no one may have a fire, lighted lamp or candle in any vessel without authority's permission. (The authority may make bye-laws covering the use of fires and lights). Guns must be unloaded and no gunpowder may be brought into the harbour without permission.

*See Vol. XLI, March 1960, p. 357.

Fire, of course, still remains a serious danger. If any combustible cargo or material of any kind is placed on quays or other works, or is on a ship's deck in the harbour, the owners of it or those in charge of the places where it is, must remove it within two hours of notice to do so from the harbour master. If it is to remain overnight it must be properly guarded. The harbour authority may do this if necessary, and charge the owner with the cost. In view of the widespread and senseless hooliganism which occurs, this provision is of some importance. Under the criminal law setting fire to or damaging vessels of any description, including those in course of construction, is a serious felony. So also is the theft of any goods from any vessel or port.

The handling of oil is now governed by the Oil in Navigable Waters Act 1955. Generally speaking it is an offence to discharge oil or a mixture containing oil within territorial waters, including the waters of a harbour. Harbour authorities may appoint places within their limits and fix times and conditions for the discharging of water ballast from vessels which have carried cargoes of petroleum spirit.

It is equally an offence if the discharge into the waters of the harbour is from a " place on land ". The term " place on land " has a very wide meaning and covers anything resting on the sea bed or sea shore and anything afloat, not being a vessel, if it is anchored or attached to the land. Discharges of oil may, however, be made for the safety of a vessel, for preventing damage to vessel or cargo, or for saving life.

The Act empowers harbour authorities to provide oil reception facilities for the discharging or depositing of oil residues and to make reasonable conditions and charges for their use. The Minister of Transport and Civil Aviation may also direct harbour authorities to provide such facilities if they are non-existent or inadequate.

But this power is subject to limitation. Harbour authorities cannot be obliged to make these facilities available for tankers or to enable a vessel to carry out repairs. Nor need such facilities receive untreated ballast water, that is ballast water containing oil.

Oil must not be transferred to or from any vessel in any harbour in the United Kingdom between sunset and sunrise unless notice has been given to the harbour master. Such notice may be of two kinds, notice of a particular transfer which must be given not less than three or more than 96 hours beforehand; or it may be a general notice for a period of up to 12 months that there will be frequent transfers and specifying the place in the harbour.

The owner or master of a vessel or of a " place on land " must report discharges of oil into the waters of a harbour to the harbour master. This applies where the oil has escaped or where it has been legitimately discharged for safety reasons or to prevent damage.

Apart from the discharge of oil, ballast and other material, earth stones and so on, must not be thrown into a harbour. But there is an exception of importance to riparian owners, when the purpose is to recover land lost through the washing or scouring action of a navigable river or to protect land which is being lost by such river action.

If a vessel or a float of timber, or the persons employed in connection with it, cause damage to the quays or other works of a harbour the owner will usually be liable, negligent or not. This rule is, however, subject to some qualification. Shipowners are not liable if their vessel causes damage after it has been abandoned if the situation was so perilous that the crew were forced to leave it. Circumstances amounting to force majeure or inevitable accident may also exempt shipowners from liability if they have not been negligent. Moreover, shipowners whose vessel collided with dock gates and so damaged them as to stop another vessel from entering the harbour have been held not liable to the vessel so delayed.

When there is liability the person in charge of the vessel or timber float may have to make good the damage he has wilfully or negligently caused.

The remedy of the harbour authority, when their property is damaged by a vessel is to detain it, if necessary, until security has been given for the damage. This is a statutory power. When it is exercised the authority obtains a possessory lien which overrides other maritime liens.

The authority may recover damages of up to £50 in summary proceedings before the justices who may order the property causing the damage to be sold to meet them. Shipowners who have had to pay damages may recover from the person in charge of their vessel if it is his fault. Finally their liability in damages is limited by the Merchant Shipping (Liability of Shipowners and Others) Act 1958.

Bye-laws were mentioned earlier in connection with fires and lights. Harbour Authorities may make bye-laws which must not conflict with the laws in force in the locality. The bye-laws may deal with such matters as the use of the harbour, the powers of the harbour master, the admission of vessels into the harbour, their good order and government within it and their removal. Hours of opening of dock gates, the handling and warehousing of goods with the consent of customs and excise, the duties and the conduct of all persons in the harbour, other than customs officers, safety, use of appliances and harbour administration generally may also be included.

Where docks or basins in a port are used by emigrant ships the authority may make bye-laws relating to the landing and embarking of the emigrants, for access and the handling of their luggage.

Bye-laws made by a harbour authority require confirmation. The confirming authority is, as a rule, a high court judge or the justices in quarter sessions. One month's notice of the proposed bye-law must be published in a local newspaper and a copy must be exhibited in the principal office of the authority for public inspection. Copies of bye-laws which may be enforced by fines, must be supplied to any person free of charge. Such bye-laws may be altered or repealed at any time

Traffic at the Port of New York

According to an announcement recently published by the Port of New York Authority, there was a sharp rise in imports at the port during 1959 which more than offset the decline in exports, raising the annual general cargo traffic figures to 13,091,702 tons, 8.4 per cent over those for 1958. The general cargo exports continued the downward trend begun during the 1958 recession amounting in all to 4,988,064 tons, a fall of 5.8 per cent compared with the previous year. In particular, trade with Latin America declined.

Imports, on the other hand, totalled 8,103,638 tons, an increase of 19.5 per cent, and the highest figure obtained by the port during the past 23 years. Trade with the Western European market rose 33 per cent to 2,485,120 tons although ore exports declined; trade with the Middle East and Africa was steady; trade with the Far East showed increases in both exports and imports. Altogether, the port's share of United States general cargo fell during the year, despite the rise in cargo tonnages.

The Port Authority awarded contracts valued at more than $4.5 million for the construction of further marine terminal and berthing facilities in Brooklyn and the new Port Elizabeth area. One contract is to build the initial portions of a quay which will extend 1,060-ft. along Newark Bay and 600-ft. along the north side of the Port Elizabeth channel. Another contract is for work on the new Pier 8 in the Baltic Terminal area of Brooklyn.

A Mean Sea Level Investigation

Tying Up the French and British Datums

By A. J. WOODS (Kelvin & Hughes Limited)

A short description of the methods used to obtain a current profile across the Straits of Dover as part of the work involved in the correlation of the mean sea level on the French and English Coasts.

EUROPEAN geodesists have been working for years to unify the various levelling networks on the Continent. The work on levelling across the English Channel was started by J. Crease of the National Institute of Oceanography on the suggestion of the Ordnance Survey in 1958. In October, 1959 the following resolution was passed at Liverpool: "The International Commission for European Levelling . . . . with representatives of the International Permanent Service for Mean Sea Level took note with the greatest interest of the work done by M. M. Crease and Cartwright concerning the connections between the heights in France and Great Britain. It hopes that this work will be continued by all other existing methods and will be applied particularly to connections between the regions of Calais and Dover, and between points to be selected on the coasts of Great Britain . . . . and of Belgium and Northern Ireland . . . . ." (Reference No. 5.)

An important step in this project is the tying together of the Ordnance Datum in England and France. Levelling operations over land as is well known can attain great accuracy by repeated measurements, but the 20 miles of sea in the Straits of Dover present a barrier over which the ordinary optical methods of surveying would not be sufficiently accurate, being only reliable to about ½ metre and any improvement on this would be acceptable to the Ordnance Survey. There is an indirect method which it is thought will give sufficient accuracy and that is the hydrodynamic method which involves a consideration of sea currents and their associated gradients. It is hoped this method will give an accuracy of 1 to 2 cms. Of course the method is not simple and consideration has to be given, for example, to atmospheric pressure and wind stress, and a major factor is the Coriolis stress on the mean nett current. The first step however is to get as complete and accurate measurements as possible of the actual sea currents between Dover and Calais.

Michael Faraday in 1832 suggested a method by which sea currents might be measured. A moving mass of sea water is a conductor cutting the lines of force of the vertical component of the earth's magnetic field and so a voltage will be generated across the mass of water. A suitably placed cable would enable this voltage to be measured and hence the water current speed inferred. References 1 and 2 give details of this interesting method.

With the co-operation of the Post Office a telephone cable across the Straits of Dover from St. Margaret's Bay to Sangatte has been used in this sense and since 1953 the voltages induced in the cable have been recorded. Reference No. 2 describes how Bowden has used these voltages to give information on sea currents. The induced voltages in the telephone cable appear in the form of a trace on the paper of a recording milli-ampere meter. The trace is in the form of a sine wave with variations in amplitude according to the speed of flow of the water in the Straits. The shape of the trace should, in fact, depend upon the flow rate integrated across the whole width and depth of the Straits, but discrepancies cannot yet be ruled out. For example, if the instrument is switched off, the straight line which appears on the chart is not midway between the peaks and troughs of the tidal sine wave which is shown when the instrument is in use. This zero shift may be a measure of the mean nett flow apart from the tides. The value of these records would be greatly enhanced if a good zero for the trace could be fixed as a result of independent current measurements made over the same stretch of water, in fact along the line of the submarine telephone cable. An example of extensive current measurements done in this area is the work of van Veen (reference No. 4) but of course they cannot now be tied up with simultaneous readings of the telephone cable.

The National Institute of Oceanography determined to make an effort to get a large number of current profiles along the track of the telephone cable and the Director, Dr. G. E. R. Deacon, F.R.S., asked Messrs. Kelvin and Hughes Limited if they would co-operate in taking the measurements using their new Direct Reading Current Meter. By the kind co-operation of the Hydrographer of the Navy, the two fine survey vessels, H.M.S. Echo and H.M.S. Egeria were made available for the work. It was decided to occupy three stations with each ship for a period of 40 hours at each station, making six stations in all evenly spaced across the Straits. The positions are indicated in Fig. 1. Messrs. Kelvin and Hughes Limited provided two prototype Direct

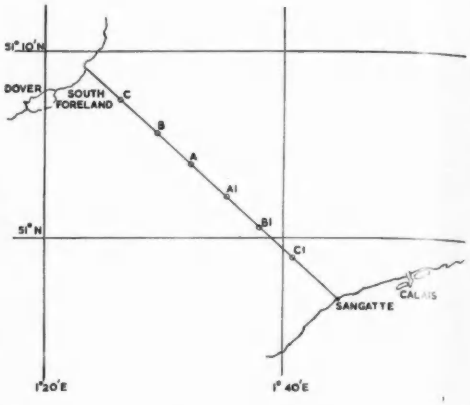


Fig. 1. The six stations.

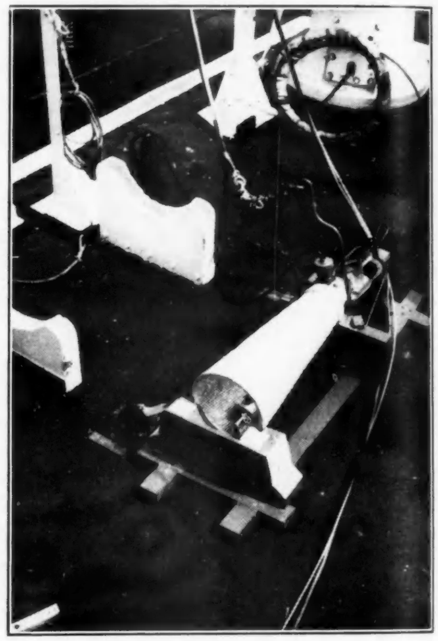


Fig. 2. The underwater gear stowed on deck between operations.

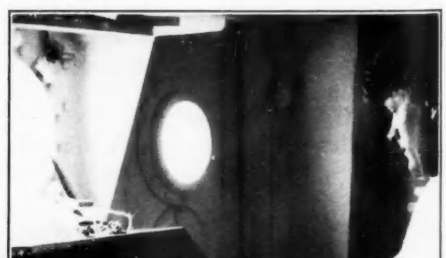


Fig. 3. The D.R.C.M. indicator unit in operation during the survey.

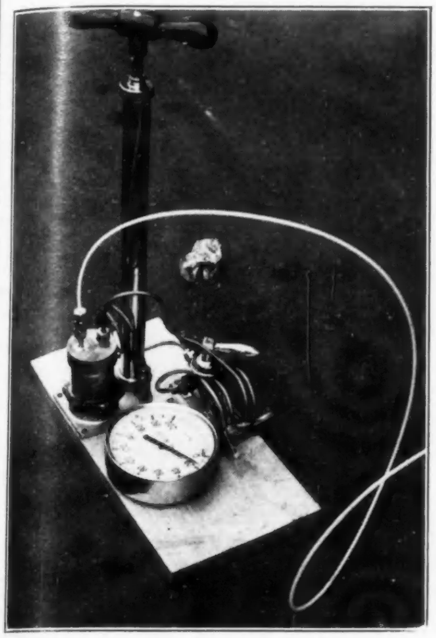


Fig. 4. The pneumatic depth indicator.

Reading Current Meters, one for each ship, and the writer also attended for the purpose of instructing personnel in their use and to share in the work of measurement. The National Institute of Oceanography provided three observers, namely, Mr. D. E. Cartwright, Mr. C. L. Gulliver and Mr. J. A. Moorey. H.M.S. Echo was in command of Lieut. Cmdr. R. G. Green and H.M.S. Egeria in the command of Lieut. Cmdr. W. J. M. Roberts.

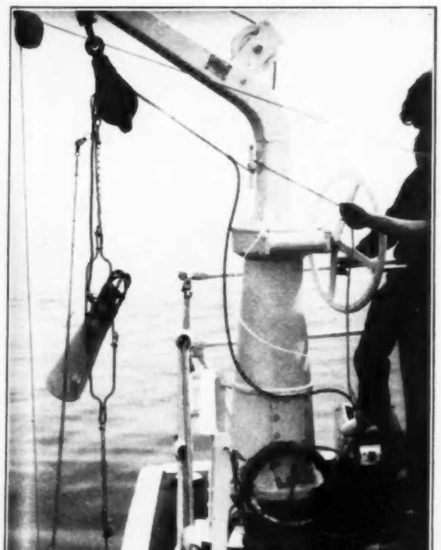


Fig. 5. The current meter rigged on H.M.S. Echo and ready for lowering.

Measuring Gear

The currents were to be measured with the Kelvin Hughes new Direct Reading Current Meter, commonly referred to as the D.R.C.M. This has been described recently[3] but it will be useful to give a very brief description here. The meter consists of an underwater gear (Fig. 2) connected by cable to an indicator unit (Fig. 3) the latter including dry batteries which supply power for the complete equipment. The speed of rotation of the propeller is shown on the left hand dial directly as speed of water movement in knots. The right hand dial gives the angle between the magnetic meridian and the direction of flow after a simple balancing operation is performed by pressing and turning the right hand knob until the little centre meter reads near its central zero. The readings can be made and noted down with the time as rapidly as twice per minute if need be. In the present application the value of having direction as well as speed of flow consists in the possibility this gives of taking out the component of the flow which is at right angles to the section of the Straits across which the integrated water flow is required. Because this instrument is capable of giving readings of speed and direction very quickly, it was thought profiles could be taken at 10-ft. differences of depth allowing one minute for each reading. The greatest depth on the line was $31\frac{1}{2}$ fathoms (190-ft. at high tide) and so a whole profile should take 18 minutes, thus making it possible to complete profiles each half an hour.

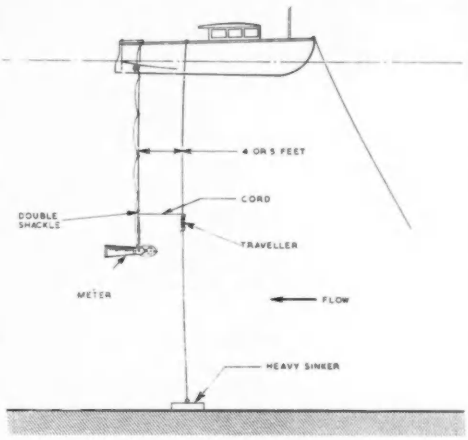


Fig. 6. The shot line rig.

Depth of Meter

Those readers who are familiar with taking current measurements at sea will not need to be told of the difficulties of getting a current meter down to the required depth or, in fact, of knowing at what depth a current meter is during a reading. To obviate this difficulty Kelvin Hughes provided a pneumatic depth indicator, illustrated in Fig. 4. This device is very simple indeed, and any repairs which may be necessary can be trusted safely to ordinary mechanics. The principle components are a hand-operated pump, a control cock, an air chamber, a pressure gauge, and a length of plastic tubing going down to an open end at the Current Meter. The method of operation is to set the control cock to " Air " then to give a number of strokes with the pump. This charges the air vessel with compressed air which immediately begins to pass down the plastic tubing and to bubble out at the underwater end. The control cock is then set to " Gauge," thus disconnecting the pump, and the gauge then reads the pressure in the air vessel; the gauge is calibrated in feet depth of sea water instead of pounds per square inch. The needle of the gauge now begins to fall and comes to rest when sufficient air has bubbled out to make the pressure of air at the open end of the pipe equal to the hydrostatic pressure at the depth. It takes much less time to do this than to describe it, although some practice was necessary at the greatest depth of 190-ft. The plastic tube is bound at short intervals to the supporting cord and electric cable which go down to the current meter underwater unit, so that the three are treated as one cord and paid out over a 6-in. snatch block.

The use of the pneumatic depth indicator removes the bugbear of not knowing the depth of the current meter but it does not remove the similar difficulty of not being able to get it down to the desired depth. In strong currents it is very difficult to get a current meter to go down to a great depth irrespective of how much supporting cord is paid out. To get over this difficulty it was decided to use the rig shown in Fig. 6. Two finned streamlined lead weights, each weighing 120 pounds, were coupled together and lowered over a pulley at the upper end of a davit on the starboard quarter of each ship. These weights were lowered by an electric winch to just off the bottom using steel wire 5/16-in. dia. The current meter was lowered from another pulley attached with a strop lower down on the davit; this pulley was the 6-in. snatch block already mentioned. A fathom of stray line connected a traveller running up and down the wire cable to the shackle swivel above the current meter; Fig. 5 shows this rig ready for lowering. Fig. 6, taken from the instruction book, shows the principle of the rig in use. It was found that for slow speeds below one knot it was better to dispense with the weighted wire and merely to lower the current meter independently with a 20 pound weight 10-ft. below it, using the shot line rig when the current was between 1 and 3 knots. At high speeds it was found

that the sea took hold of the supporting cord and cable when the meter was quite deep and stretched it into a great bight down stream. This had the effect of preventing the meter being lowered any more even though more cable was veered. The cure for this was suggested by Cmdr. Green and that was to fix wire clips at intervals to connect the cable to the shot line and remove them when not required.

A start was made on the 4th May in the afternoon when H.M.S. Echo, with Lieut. Cmdr. Roberts and some of the crew of H.M.S. Egeria went out to near the Gull Light in 47-ft. of water. The gear was rigged and practice taken in its use by personnel of both vessels.

Six stations were fixed on a line over the telephone cable which was used for the Faraday method as follows:

Station	Latitude		Longitude	
C.	51°	07.2′ N.	1°	26.5′ E.
B.	51°	05.5′ N.	1°	29.5′ E.
A.	51°	03.8′ N.	1°	32.4′ E.
A1.	51°	02.0′ N.	1°	35.4′ E.
B1.	51°	00.4′ N.	1°	38.2′ E.
C1.	50°	58.8′ N.	1°	41.0′ E.

The first three of these stations were allocated to H.M.S. Egeria and the remainder to H.M.S. Echo. The stations are shown plotted in Fig. 1.

Operations started in earnest on the 5th May and continued until the 10th May.

At each station the ship was anchored and the gear rigged as shown in Fig. 5. Two men were stationed on the poop to lower and raise the meter and to control the electric winch which lowered the heavy streamlined weights. The current meter indicator unit was rigged in the chartroom some 60-ft. forward of the davit from which the meter was being lowered. In H.M.S. Echo the depth indicator was also in the chartroom and an electric lamp operated by a key was rigged aft as a signal so that the men could raise the meter 10-ft. at a time when the observer had had time to let the instrument steady and to take and record the readings of speed, direction and depth of meter. The readings of depth were recorded as they came and these were sometimes not exact intervals of 10-ft. It was felt that this expedited the work and the exact 10-ft. intervals would be taken out of the plotted profiles afterwards. On H.M.S. Egeria the depth indicator was aft near the lowering position and the men hauled in each time till the depth indicator showed a change of depth of exactly 10-ft.

The method used was to lower the meter till a weight 10-ft. below it touched bottom and then to record the depth of the meter and the speed and direction of flow. The meter was then hauled up to the next layer and the readings taken. This procedure was repeated till the meter was near the surface. Every half hour the depth of the water was measured using the precision echo sounders with which both ships were provided. During each profile, notes were also made of the weather which was excellent during the whole of the measurements and undoubtedly was a very important factor and a great help in getting so many measurements.

So many measurements would not be expected without some mishaps and two meter propeller spindles were broken and replaced from available spares. The cone tail of one meter was lost and temporarily replaced by a "jury-rigged" tail whilst radio contact was made with Kelvin and Hughes who sent a replacement to Dover. Readings were interrupted whilst a trip was made to Dover to collect this replacement. One ship had to make two trips to Dover to land and re-embark a man for compassionate reasons. All these emergencies were dealt with expeditiously by the ships' companies and the radio communication between the ships was a great help.

The total number of readings which would have been recorded, had every one possible been taken, would have been 6,640,

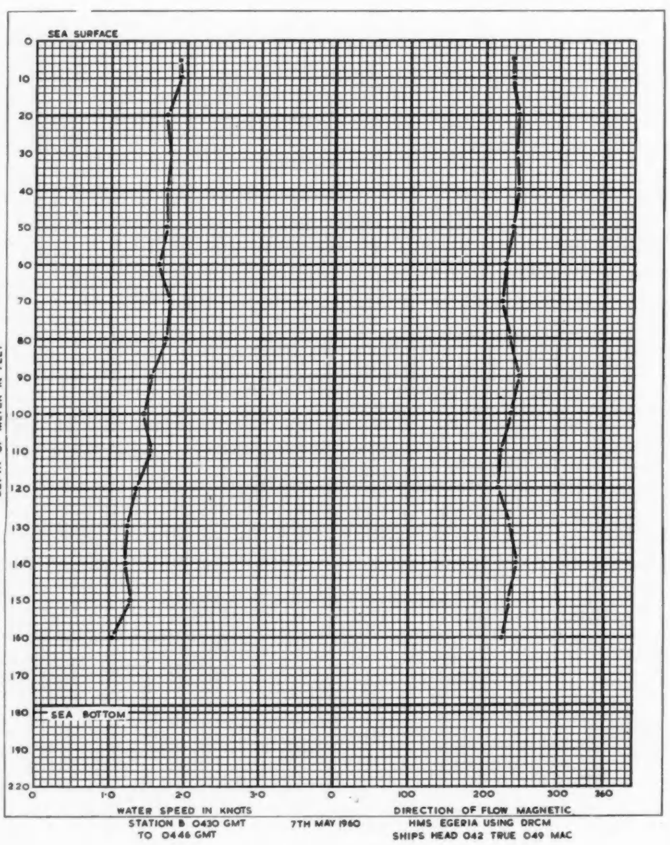


Fig. 7. Current Profile at Station B.

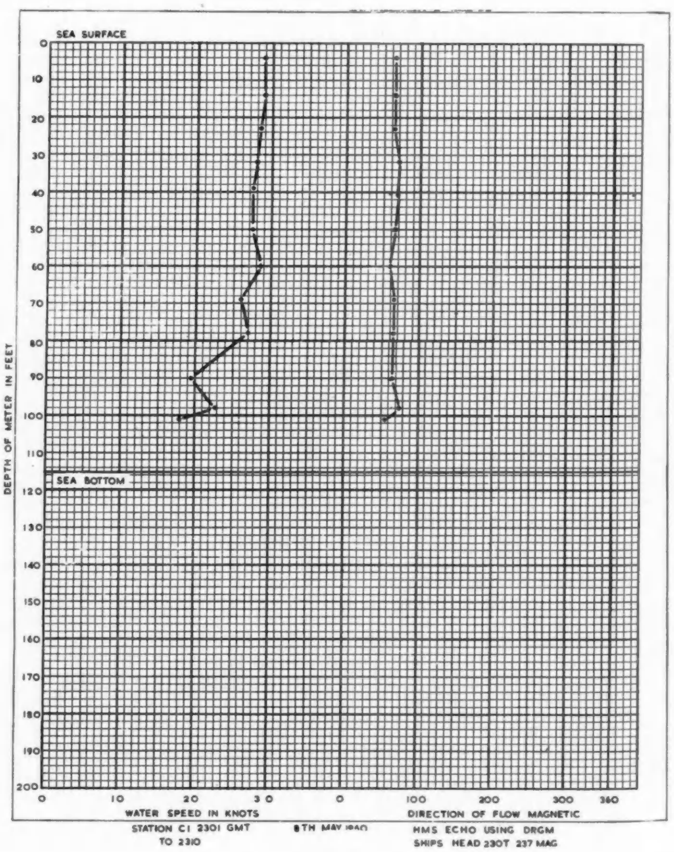


Fig. 8. Current Profile at Station C1.

but in fact over 6,000 readings were taken and 444 complete profiles were taken, each one showing the speed and direction of the current for 10-ft. intervals of depth. The important point is that in nearly every case the depth of the current meter was actually measured and not estimated so that depth of the meter was known to an accuracy of one or two feet, for every measurement. Out of 444 profiles two representative ones have been taken at random and reproduced in Figs 7 and 8. To have achieved 92% of all possible readings on such an arduous exercise as this one is thought to be a very satisfactory result.

Commander Gordon, Superintendent of Tides, Admiralty, who was present at the practice runs on May 4th, has suggested that persons who are not familiar with all the facts might form incorrect assumptions about the tidal streams in the area from a cursory examination of Fig. 7 and Fig. 8. The minor " kinks " in these curves may be due to a combination of small observational and instrumental errors and movements of the ship. During the analysis of all the results such minor " kinks " would be smoothed out where it is shown to be appropriate by the whole series of profiles taken at each station.

All the readings are now in the hands of the National Institute of Oceanography where Mr. Cartwright and his colleagues are applying their mathematical techniques so that they can be related to the variations in the voltage along the underwater telephone cable. This will be the first stage in calculating the gradients and so eventually giving the difference in mean sea level on the English and French sides and from this to tie up the ordnance datum in England with the ordnance datum in France. These results will be published as soon as the work is completed.

Acknowledgments

The writer has produced this article at the suggestion of Dr. Deacon and he acknowledges the kind permission to publish from Mr. G. Wikkenhauser, M.B.E., Chief Engineer of Kelvin and Hughes Limited.

We were fortunate to have in H.M.S. Echo, Lieut. Cmdr. Glen of the Tidal Branch Hydrographic Department of the Admiralty who shared the measuring work with us. The help and encouragement of Lieut. Cmdr. Green and Lieut. Comdr. Roberts greatly smoothed the working through of this exercise and the cheerful help of both crews is gratefully acknowledged. The writer's thanks are due to Mr. D. Cartwright for reading this paper and making valuable suggestions.

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Book Reviews

Use of X-Rays in the Detection of Teredo in Wood by A. C. Oliver, M.Sc. Test Record B/TR/2 Published by the Timber Development Association, Ltd., 21 College Hill, London, E.C.4, price 3s. 6d.

For some years the Timber Development Association has been carrying out tests at Shoreham Harbour in Sussex to assess the natural resistance of various timber species to marine borers. More recently, tests have been initiated in collaboration with the British Wood Preserving Association on samples of beech treated with various proprietary timber preservatives. In both tests sample blocks 6 in x 6-in. x 3-in. are used. Until recently the performance of the samples was checked periodically by visual examination but in 1959 a portable X-ray set was used for the first time. A discussion of the technique used and the results obtained is now given in this publication.

The author states that the X-ray affords a quick, easy and reliable technique for assessing the extent of Teredo attack on sample wood blocks. The method is non-destructive and does not necessitate permanent withdrawal of sample blocks at inspection. The rate of attack can be studied over a period in individual test blocks. He expresses the view that in all probability all marine boring molluscs can be detected by X-rays, so that the technique should be applicable all over the world where research on marine borers in timber is carried out.

" Sponsored Fire Resistance Tests on Structural Elements." Published for the Dept. of Scientific and Industrial Research by H.M. Stationery Office, price 7s. 6d., by post 8s. (U.S.A. $1.35).

A knowledge of the behaviour of the structural elements in fire is necessary in designing buildings which will give adequate protection to their occupants whilst at the same time limiting the extent of any fires which may occur. Since 1935 large scale tests have been made under controlled conditions in this country to measure the fire resistance of full scale parts of buildings. At first, research was centred on finding how common or traditional materials and forms of construction behaved. The results of these investigations were included in the schedules of local authority bye-laws to show methods of satisfying the fire resistance requirements for buildings.

Subsequently the Joint Fire Research Organisation has had a growing demand from industry for tests on proprietary materials and forms of construction and in recent years much valuable information relevant to modern building methods has been accumulated. The data sheets, covering several years testing have now been published by the Organisation with the co-operation of various firms. Full details are given of the materials and methods used in constructing the test specimens so that those selected for a particular job may be reproduced as closely as possible in service.

The Joint Fire Research Organisation is jointly run and financed by the Department of Scientific and Industrial Research and the fire insurance companies who are members of the Fire Offices Committee, together with practically all the independent and mutual offices.

The Design of Sea Defence Works by R. Berkeley Thorn, B.Sc., A.M.I.C.E., A.M.I.Struct.E., A.H.I.W.E. 106pp., illustrated. Published by Butterworths Scientific Publications, 4 and 5 Bell Yard, London, W.C.2. Price 25 shillings, postage 1s. 3d.

The maintenance and strengthening of natural sea defences are the first aims of the sea defence engineer. Coastal conditions seldom attain complete year-to-year stability and engineers are therefore faced with the problem of a deteriorating foreshore, which, unless it can be (or becomes) stabilised by one means or another, will require continuous additional works. Until comparatively recently, design of sea defence works has proceeded by trial and error methods which have not always been successful and, although much detailed research is at present being carried out on the subject, there are still many problems to be solved. To avoid costly failures it is imperative to understand the basic factors affecting the foreshore conditions and to try and design from the accumulated knowledge of these factors, sea defences that will fulfil the requirements with the minimum expenditure.

No man can have a completely comprehensive knowledge of any subject and in his Introduction Mr. Thorn frankly admits his limitations. However, this book is based on his experience of design and construction of millions of pounds' worth of works carried out on over 150 miles of sea defences maintained by the Kent River Board. These defences range from sand dunes to earthen estuary walls and from timber groynes to huge structures such as the Northern Sea Wall from Reculver to Birchington, which is one of the largest sea walls in the United Kingdom.

This book represents the first scientific approach to the subject of sea defences and every effort has been made to include and refer to the results of the relevant research on the subject. It also contains a useful contribution on American design methods by Thorndike Saville Jr., of the U.S. Army Corps of Engineers, Beach Erosion Board. It should be a valuable addition to the reference shelves of maritime authorities throughout the world and to all those interested in shore stability.

Marine Salvage Operations by Edward M. Brady. 256 pages. Published by the Cornell Maritime Press, Cambridge, Maryland, U.S.A., price $8.50 and obtainable in Great Britain from Putnam and Co. Ltd., 42 Great Russell Street, London, W.C.1, price 75s.

In this book, Mr. Brady who is a surveyor of the United States Salvage Association, Inc., concentrates on actual ship salvage operations as distinct from the preservation and saving of material. He comments in his preface that " since earliest times, salvage has been an arduous and often frustrating task. With the passage of time, one might be led to expect that salvage would become easier because of the improvement in equipment and the development of specialised techniques. However, this generally has not been the case for, even though equipment has improved, the size of the task has enlarged proportionally. This can be seen in the increase in size of vessels over the years in conjunction with the increasing complexity of their design. The result is that, in time, although we improve methods, as a result of time, we must apply them to a larger problem: one seems to balance the other—a requirement of nature."

In marine salvage, there are three general types of salvage operations: strandings, sinkings and rescue towing. The author covers fully the principles and practice of each type of operation, together with preliminary background material. In a chapter devoted to diving both in shallow water and deep sea, the equipment and gear used is discussed, and mention is made of undersea sleds and diving boats. Another chapter on naval architecture includes a basic study of the fundamental hull structure of a vessel, buoyancy and stability and the effects of changing and shifting weights in a vessel. Here, however, Mr. Brady insists that theory alone is no substitute for practical experience. It should be used to augment it.

The chapter on structures and equipment used in salvage work covers a wide range and deals in considerable detail with marlinspike seamanship, patches, cofferdams, air lifts, etc. The methods used in each category of salvage practice are described at length elsewhere in the book, and there is also a section on miscellaneous salvage operations, techniques and hazards.

The book is very well illustrated with diagrams and sketches to convey the author's methods and there is also an index for easy reference. It should be of considerable value to all those interested in salvage work.

Mechanisation at Port of Melbourne

Pool of Mobile Handling Equipment

Since 1945, the Melbourne Harbor Trust has embarked on an intensive port mechanisation programme, in order to enable the waterfront labour force to handle more easily a greater volume of cargo and ensure a faster turn-round of shipping.

Mechanisation of the port started in 1930, when the first 3-ton electric wharf crane was installed at Station Pier, and although it has been gradually extended since then it is only in the post-war years that it has become a feature of the port.

Today the Trust owns and operates 53 electric wharf and shed cranes of 3, 6 and 7½-ton capacity, as well as a floating crane of 40 tons, and a steam shore-based crane of 60 tons. A pool of mobile cargo-handling equipment includes 35 mobile cranes, ranging from 2-tons to 10-tons capacity; 74 fork lift trucks, of between 4,000 lbs. and 18,000 lbs. capacity; there is also a stillage truck and a bag stacker, 2 load grabs of 2,240 lbs. and 3,350 lbs. capacity, 2 straddle trucks and 8 over-loaders to supplement the much larger fleet of privately-owned equipment operating in the port under Trust supervision.

The Harbor Trust Commissioners have established the pool for three main reasons.

1. To set the pattern of the type of equipment which could assist in cargo handling.
2. To set a standard of maintenance and safety for all the equipment operating in the port.
3. To supplement privately-owned equipment in peak period cargo traffic.

Today the pattern has changed, and the pool is in such demand that the port authority is actually being criticised for not providing enough equipment. The basic reason for this change lies in the fact that the Trust can operate and maintain a fleet of mobile cargo-handling equipment more economically and efficiently on a time-worked basis than can private companies. Unless a stevedoring company, a shipper or consignee has a constant need for a particular type of machine or machines, the capital outlay involved cannot be matched with a full-time-worked return.

Economy in Hiring Plant

The Trust pool allows a stevedore to call for the type of equipment suited to the particular cargo in a particular ship, a type of equipment which he may not call on again for a period of months, and it has therefore become more economical to hire the required equipment with skilled operators.

This trend is particularly evident in revenue returns. In 1945, the Trust's return from hiring fees of mobile equipment, comprising a limited pool of mobile cranes and fork lift trucks, amounted to 1.6% of total revenue, which, together with returns from wharf cranes, brought a combined total of 4.6% of gross port revenue.

By 1951, straddle trucks had been added to the pool, and the revenue had risen to 6.3%, and combined with wharf crane revenue now amounted to 11.1% of the total port revenue which was mainly made up of wharfage and tonnage rates.

In 1957, overloaders were added to the pool to handle coal and phosphatic rock discharged from ships at Appleton Dock on to a wide expanse of ground storage area behind the berths for removal by road transport. Revenue returns had then grown to 7.9% with a combined total of 13.6% of gross revenue.

The steady rise continued until in 1959 the percentage was 9.3% for mobile equipment, with a combined total from all cargo-handling equipment of 16.3% of the port's revenue for the year.

It is also worthy of note that mechanisation has not had any substantial effect on labour requirements—a fact which has also been evident in other countries. Mechanisation can and does help a labour force to handle more cargo efficiently and speedily.

A Highway Tunnel under the Kiel Canal at Rendsburg

Description of Construction Works

(Specially Contributed)

The German province of Schleswig-Holstein is traversed by a trunk road belonging to the system of European long-distance highways. This road, which is designated as "Europastrasse No. 3", intersects the Kiel Canal, one of the busiest and most important waterways in the world, linking the North Sea with the Baltic Sea.

The road crosses the Canal at Rendsburg by means of a swing bridge which was completed in 1914. This bridge has an overall length of 164 m. and carries a 7.64 m. wide carriageway. During the first fifteen years of its existence the bridge was used by traffic consisting for the most part of horse-drawn vehicles, cyclists and pedestrians. Even as late as 1930 the average number of motor vehicles crossing the bridge each day was under 300. By 1958 this number had increased to 10,300. At the present time, peak figures of over 12,000 vehicles crossing the bridge in one day have been recorded, with, in addition, some 7,500 cyclists and 8,000 pedestrians per day. The volume of shipping using the canal went up from 54,600 vessels (in 1913) to 70,000 (in 1958). These last-mentioned figures are not spectacular in themselves, but they acquire added significance when it is pointed out that the total annual tonnage of the shipping represented by them increased more than threefold over the period under consideration.

In consequence of this increase in the number and size of the vessels, the bridge has to be opened at more frequent intervals and for greater lengths of time, with considerable delay and inconvenience to the road users. To make matters worse, the bridge is also a serious hindrance to navigation, forming a sort of bottleneck in the Canal.

Not long after the Second World War it thus became apparent that complete segregation of the two traffic routes—the highway and the waterway—was imperative.

In 1952 plans were drawn up for the construction of a by-pass road which would avoid the town centre of Rendsburg and would intersect the Kiel Canal at a point some 500 m. westward of the existing swing bridge. In order to obviate delays at the Canal crossing it was clearly essential to apply complete "grade separation" as regards the road traffic and the shipping—either by means of a highway tunnel under the Canal or by means of a high-level bridge. A bridge providing 42 m. headroom above the water level would, with its approaches, have an overall length of about 2,400 m., as against not much more than half that length for a tunnel (with its invert located about 20 m. below water level) together with its access ramps. A further consideration in favour of the tunnel was that it would not mar the local scenery and that, although it would cost more to construct than a bridge, its operating and maintenance costs would be lower. For these reasons it was decided to build a tunnel to carry the by-pass road under the Canal and, in addition, a second tunnel for the use of local pedestrian and cycle traffic. The latter tunnel was to be quite independent of the main tunnel and be located close to the swing bridge.

Fig. 1. Key Plan showing location of tunnel.

General Description of the Tunnel

The main highway tunnel is intended for vehicular traffic only. The access ramps have a 1 : 25 gradient. At its lowest point

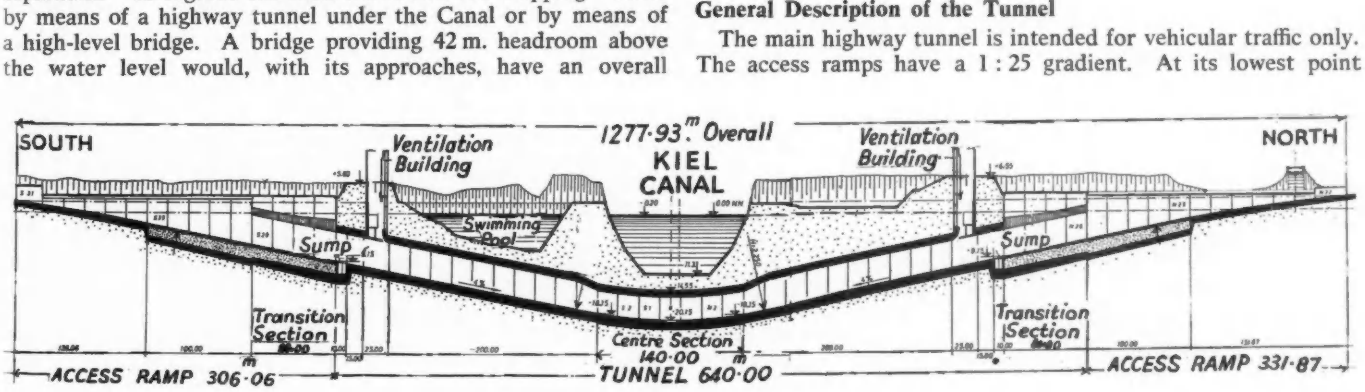


Fig. 2. Longitudinal section of the tunnel.

the carriageway is 19.95 m. below the normal water level in the Canal, which has a depth of 11.13 m. At this point the top of the tunnel is 3.22 m. below the bottom of the Canal, thus providing an ample margin for possible subsequent deepening of the latter.

The overall length of the tunnel, including the ramps, is 1,279 m. The south ramp is 227 m. long and is connected to the actual tunnel by a transition section with a length of 80 m. The corresponding dimensions for the north ramp are 252 m. and 80 m. The covered portion, constituting the tunnel proper, has a length of 640 m. It is a twin structure, each longitudinal half of which accommodates a 6.80 m. wide two lane carriageway. The transition sections are covered with a kind of grid, formed of precast

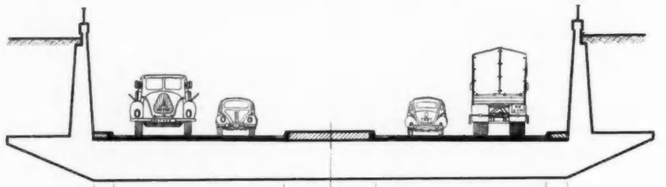


Fig. 3. Section through access ramp.

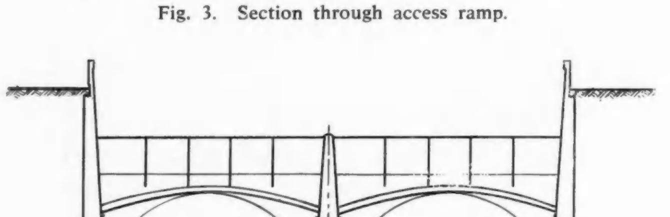


Fig. 4. Section through transition portion of ramp.

concrete units, which partly screens the daylight and thus provides a transition from the relatively bright natural lighting conditions on the access ramp to the relatively dim artificial lighting within the tunnel itself, and vice-versa. In addition, the grid structures serve to strut the side walls of the ramp apart and thus help to resist the earth pressure.

Almost the entire structure, including the ramps, is located below the ground-water level. The ramps are formed by an open trough-like structure provided with a reinforced concrete floor of considerable thickness and sufficient weight to overcome the buoyancy uplift. The floor is moreover provided with lateral cantilevered portions which help to maintain stability in virtue of the vertical earth pressure acting upon them. The internal faces of the side walls have a 15 : 1 batter.

The twin tunnels, each accommodating a carriageway, are separated from each other by a 1.20 m. wide service walkway, with a cable duct running above it. Transverse connections between the two tunnels are provided at intervals of 40 m., so that the walkway can also be used as an escape route in an emergency. Fire-fighting equipment (hydrants and foam extinguishers) and telephones are provided at strategic points along the tunnel. Under the floor of the walkway is a drainage channel. The carriageways, which have a cross-fall towards their common centre-line, drain into this channel, which conveys the water to a sump at the lowest point of the tunnel.

The 140 m. long centre section of the tunnel has a shallower, more rectangular cross-section than the rest of the tunnel. The tunnel and its access ramps are of reinforced concrete construction throughout. The internal wall surfaces are formed of the exposed concrete, without rendering or lining of any kind. Externally the entire structure has been made waterproof by the application of from three to five layers of bitumen felt in conjunction with 0.2 mm. thick aluminium foil. The centre section is additionally protected by a sheathing of steel plate 6 mm. thick.

The tunnel is equipped with continuous fluorescent strip lighting attached to the roof. Automatically operated switchgear

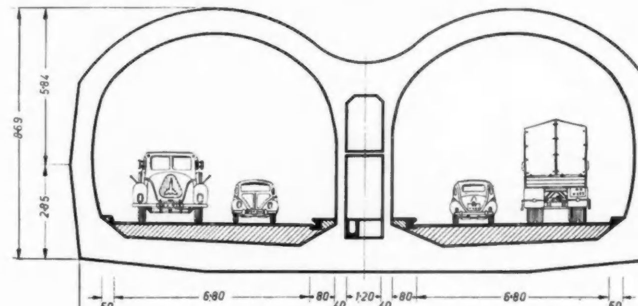


Fig. 5. Section through cut-and-cover portion of tunnel.

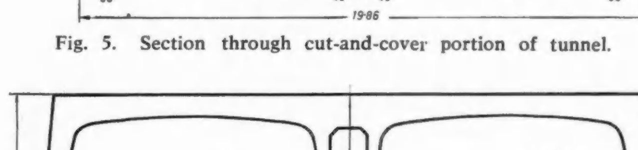


Fig 6. Section through 140 m. long central prefabricated portion of tunnel.

reduces the lighting intensity at night. When the lights are "full on", the illumination provided at all points of the carriageways is about 100 lux. The access ramps are lighted by powerful lamps mounted on standards installed on the central reservation.

An important feature of the tunnel equipment is the ventilating system for removing the exhaust gases of the motor vehicles. During its passage through the tunnel a car will produce, on an average, about 150 litres of carbon monoxide. To render this amount of gas harmless, it is necessary to provide a dilution of 4,000 times, i.e., 600 cubic metres of free air have to be supplied to the tunnel for each vehicle that passes through it. The ventilating system is of the "longitudinal" type: fresh air is blown into the tunnel, in the direction of movement of the traffic, from a point situated inside the tunnel a short distance from the entrance portal. This arrangement produces a kind of jet action which draws in additional fresh air through the portal. Besides, the "piston action" of the vehicles helps to convey the air through the tunnel and out at the other end. Three large electric 30-kW ventilation fans are installed at each end of the tunnel. They are 2.00 m. in diameter and operate at 636 r.p.m.

Surface water on the ramps is prevented from entering the tunnel by the provision of collecting tanks of 200 m³ capacity, equipped with sand traps and inlet gratings for intercepting the water flowing down the ramps. These tanks in turn are drained

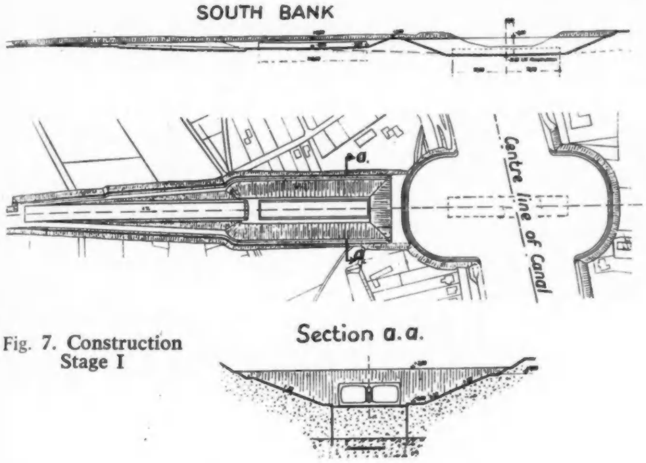


Fig. 7. Construction Stage I

by three pumps capable of delivering 3,000 litres/min. Water used for cleaning the tunnel (and such small quantities of surface water as may get past the intercepting gratings) is discharged into the drainage channel laid under the central service walkway. This channel conveys the water to a 10 m^3 sump located at the lowest point of the tunnel whence it is removed by three pumps of 665 litres/min. capacity, which return the water to the main collecting tanks at the tunnel entrance.

All these various installations are controlled from a central control room in the southern ventilation building. The electric power requirement of the tunnel and its ancillary plant is 600 kVA; current at 15 kV is supplied through three transformers which are accommodated in the northern ventilation building. A 320 kVA (435 H.P.) standby diesel generating set is available for keeping the lighting and ventilating equipment in operation in the event of a breakdown of the mains supply.

The traffic control centre is a glass-enclosed cabin located at the lowest point of the tunnel. It is built into, and forms an integral part of, the service walkway between the two carriageways and is equipped with a variety of up-to-date traffic supervision and control appliances which give the official on duty a continuous and complete picture of what is going on at all significant points along the tunnel and its access ways (television, optical and acoustic signals, telephone, etc.).

Construction Procedure

The classical method of construction for under-water tunnels in soft ground is by means of the shield tunnelling method. As the excavation work is carried out below the ground-water level, the men in the shield have to work in compressed air. This method of tunnel construction has the great advantage of not interfering in any way with the shipping using the waterway, but unfortunately it could not be employed at Rendsburg on account of adverse subsoil conditions. The only practicable solution to the problem was provided by the "caisson" method, for which there were a number of internationally famous precedents. In this method the tunnel structure is prefabricated in one or more segments which are provisionally closed at the ends, so that they can float. Each segment, which may be built in a dry dock or on a slip, is launched more or less in the manner of a ship. It is then towed into position on the alignment of the future tunnel and lowered—by flooding and sinking—into a trench previously excavated on the bottom of the waterway.

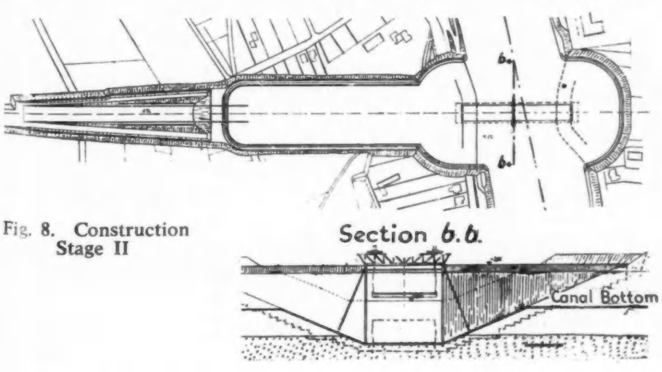


Fig. 8. Construction Stage II

The contract for the construction of the highway tunnel under the Kiel Canal was awarded, in October 1957, to a contracting combine comprising the following firms: Philipp Holzmann, Dyckerhoff and Widmann, Grün and Bilfinger, Hochtief, Siemens-Bauunion, and Wayss and Freytag. Work on the site started in November of that year. The time allowed for the completion of the job was 3½ years.

The construction procedure adopted for the construction of the tunnel can be summarised as follows:

(I) The first step in the execution of the work consists in dredging the trench (to a depth of 22 m. below Canal water level) for accommodating the future tunnel. At the same time, part of the open cut for the construction of the south access ramp is excavated. This excavation serves as the "building dock" for the 140 m. long centre section of the tunnel, which is to be prefabricated as a single unit.

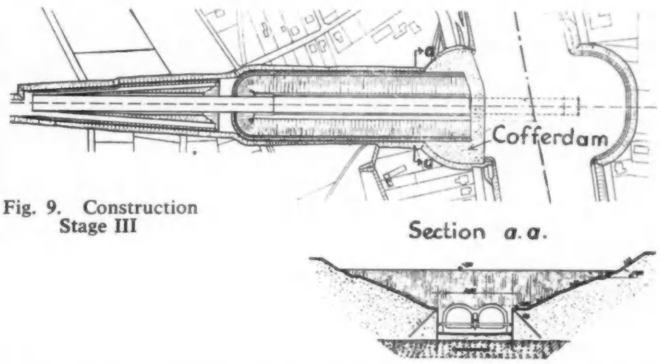


Fig. 9. Construction Stage III

(II) When the centre section has been completed in its dock and its ends have been sealed off, the dock is flooded. This causes the centre section to float. The earth dam between the building dock and the Canal is then removed by excavators, and the centre section of the tunnel is towed into position ready for sinking. For this purpose it is secured to two working platforms supported on piles driven into the Canal bottom.

(III) After the centre section has been sunk into its final position, a cofferdam is constructed across the mouth of the excavation which previously served as the building dock. The portion of the tunnel connecting the open access ramp to the submerged prefabricated centre section is then constructed in an open cut, which is subsequently backfilled.

(IV) Operations are then switched to the north bank of the Canal, where the construction of the access ramp and north section of tunnel is carried out in generally the same manner as on the south bank.

Construction of the centre section of the tunnel as a single prefabricated unit, rather than as a number of individual segments, obviates the necessity of forming watertight joints under water. The joints between the two ends of the centre section and the adjacent lengths of tunnel are constructed in the dry (within cofferdams). This method of building the tunnel furthermore involves the minimum amount of interference with shipping using the Canal.

A fair idea of the magnitude of the tunnel construction job may be gained from the following quantities:

excavation	1,100,000 m^3
reinforced concrete	72,000 m^3
reinforcing steel	3,600 tons
sheet piling (for open cuts and cofferdams)	18,500 m^2
bituminous waterproofing	54,000 m^2
steel-plate sheathing (for centre section of tunnel)	6,000 m^2

Execution of the Work

The concrete for the construction of the south ramp, south tunnel section and centre section was made in a central batching plant with a capacity of about 45 m^3 per hour. It was conveyed and placed by pumping. All the structural concrete had a specified minimum 28-day strength of 300 kg/cm^2. Five tower cranes were employed on the site and greatly facilitated the steel fixing and shuttering operations.

Excavation of the open cut for the construction of the south access ramp was carried out by means of three draglines, each of 1.8 m^3 bucket capacity. As a good deal of this earth-moving work had to be done below ground water level, well-point dewatering was employed. On the south bank this involved the sinking of 28 wells of 1,100 mm. diameter to a depth of 30 m. These wells discharged the water at a rate of 2,000-2,800 m^3/hour. The trench on the bottom of the Canal itself was dredged by a multi-bucket dredger. This was a somewhat difficult operation on account of the presence of boulders in the subsoil and the need for taking precautions to ensure the safety of the shipping on the Canal.

By December 1958 the 140 m. long centre section of the tunnel was completed in its building dock. Some 7,600 m^3 of reinforced concrete had gone into its construction, and—when floated—it had a displacement of 20,000 tons. In addition to the bituminous waterproofing applied to the tunnel structure generally, the centre section was completely sheathed in 6 mm. thick steel plate applied in the form of panels 20 m. by 6 m. in size which were fabricated from smaller plates by welding. The main object of this sheathing was to give protection against mechanical damage during the operations of floating the centre section into position and sinking it. The steel sheathing to the sides and soffit of the centre section served as the external shuttering for the concrete. The internal shuttering was of timber. Before the building dock was flooded, the centre section was tested by applying an internal hydrostatic pressure corresponding to a head of 800 mm, which was found to remain unaltered for a period of over nine days. Towards the end of January 1959 the centre section was floated by admitting water into the dock.

While the centre section was being constructed, the piles for supporting the working platforms from which it was to be lowered into its final position were driven into the Canal bottom. The important operation of towing and sinking the centre section involved closing the Canal to shipping for a period of 70 hours. The structure was suspended from four rods which were attached to its four corners and which were in turn suspended from four 150-ton hydraulic winches mounted on the working platforms.

Prior to the execution of the sinking operation, about 1 m. depth of gravel had been dumped in the trench on the bottom of the Canal and had been levelled with the aid of a special device. weighing 40 tons, which acted more or less on the principle of a bulldozer blade. It was moved backwards and forwards (on rails) by means of wire ropes operated by heavy winches installed on the Canal banks. The rails on which this device travelled were shaped to the longitudinal curvature of the soffit of the centre section of the tunnel, so that the surface of the gravel filling was graded to the correct profile.

The excavation of the open cut in which the south access ramp was to be constructed proceeded concurrently with the excavation of the building dock for the centre section of the tunnel. The so-called transition sections of the ramps were covered with an open grid of precast beams, the object of which was to provide partial screening of daylight and also to strut the high side walls of the ramps. The bituminous insulation applied to the external surfaces of these walls was protected by a brickwork backing from possible damage during backfilling.

To enable work on the south access ramp to continue after flooding the building dock, a sheet-pile bulkhead was constructed across the southern end of the dock, thus cutting it off from the actual ramp excavation. The south ramp was completed by the end of August 1959.

As soon as the centre section of the tunnel had been sunk into position, the cofferdam across the mouth of the south excavation was constructed. It consisted of two sheet-pile walls spaced 18 m. apart and connected by bracings and tie-rods installed by divers. The steel sheet piles used for the purpose were up to 26 m. in length and were driven by piling frames mounted on barges. The space between the sheet-piles walls of the cofferdam was filled with 40,000 m^3 of earth.

An essential feature of the cofferdam was that it had to enclose the end of the prefabricated centre section of the tunnel, so as to provide a watertight connection at this point. The sheet piles lowered from above on to the centre section had their ends set in a transverse channel-iron filled with bitumen. The watertight connection on the underside of the tunnel structure was more difficult to achieve. Before the centre section was placed, a sheet-pile wall had been driven into the Canal bottom and the piles cut off by divers about 40 cm below the future soffit level of the centre section. The "gap" between the top of this sheet piling and the soffit of the prefabricated tunnel structure was rendered impermeable by grouting the gravel filling of the underwater trench with a mixture of bentonite and cement, which was injected under pressure through vertical steel pipes installed on both sides of each sheet-pile wall of the cofferdam.

When the south cofferdam had been completed, the open cut which had previously served as the building dock was dewatered and further excavated. Two longitudinal sheet-pile walls, 24 m. apart, were driven into the bottom of this excavation. The sheet piles extended down to the impervious subsoil stratum. Within the protection of this sheet piling further excavation was carried out, and the portion of the tunnel linking the access ramp to the submerged centre section was constructed on the "cut and cover" principle. Like the soffit and side walls of the access ramp structure, the tunnel structure was provided externally with bituminous waterproofing. The sheet piles were then extracted, and the excavation was backfilled.

Construction work on the north bank of the Canal is proceeding according to the same general pattern as has been described above with reference to the south bank.

Development Works at Madeira

Work now in progress on the extension of the mole at Madeira is expected to be completed towards the end of next year. 350 metres of the full length of 550 metres are already in place although not finished. The completed mole will comprise four sections with varying depths of water alongside, ranging from 6 metres beside a 140 metre long berth to 11 metres alongside a 745 metre section.

The date on which large vessels will be able to berth at the completed structure will depend on the delivery of two new tugs which are expected to be built in Portugal. Both will be of 1,000 to 1,100 h.p. and will have a bollard pull of 18 tons . Facilities are also now under construction to supply oil fuel at the port.

The Port of Aqaba, Jordan

III. Details of the Phosphate Handling Installation

(Specially Contributed)

(continued from page 116)

In the first two articles published on the port of Aqaba in the July and August issues of this Journal, a general description was given of the historical background and of the construction of the new port with its modern handling facilities. In this present and final instalment a more detailed description is given of the bulk handling plant which was supplied and erected by Simon Handling Engineers Limited, Stockport, England.

Designed to accommodate the handling, storing and shipping of phosphate and potash ore, the plant consists of two covered stores with separate intake equipment and store-loading conveyors, reclaiming equipment in the stores, store-collecting conveyors and a shipping conveyor.

The Port Authority, who were advised on the project by Mr. B. Nagorski, U.N.T.A.O. Port and Shipping Expert, chose dump storage of materials in preference to silo storage both for reasons of economy and because of the material-flow difficulties known to be associated with silo storage. The plant is arranged so that phosphate and potash can be received and taken into store simultaneously, but only phosphate is exported at present. The form of storage was designed to prevent the loss of the very powdery ores through being blown away by the wind, and also to protect them from the occasional rain which falls in the area.

The shipping-out arrangements are designed to allow high-speed loading of any of a wide variety of vessels ranging from small freighters to ships of about 20,000 tons. The plant is designed for a continuous loading-out rate of 500 tons of phosphate per hour. The average loading-out rate for each vessel will depend of course, on its size, on the number of holds to be loaded, and on the number of hatches to each hold, but it will always be high enough for advantageous freight rates to be obtained.

The shipping tower has a retractable boom and a telescopic loading-out chute which, besides facilitating the positioning of the end of the chute in relation to the ship's hold for maximum convenience during loading, allow the boom and chute to be stowed away in safety in the tower and so protected from damage from the high winds which are experienced at certain periods of the year.

The whole terminal was designed to require very little maintenance and to incorporate simple operational techniques so that it can be run very largely by relatively unskilled labour.

Intake and Distribution

Provision is made in the design of the intake plant for arrival of phosphate in a variety of lorries with capacities ranging from 10 to 30 tons.

For each store there is a ground hopper of 70 tons capacity. Each hopper has an inlet lying flush with the roadway and covered with a steel grid. The area of the inlet, and the hopper capacity, are sufficient to allow the simultaneous discharge of two lorries. This arrangement is suitable for vehicles with either end-tipping or bottom discharge. Handling platforms have been installed, one to each hopper, to cater for lorries with neither form of automatic tipping. Each platform is of 30 tons maximum capacity and is capable of tipping a lorry to an angle of 35 degrees from horizontal.

The intake arrangements for the two stores are identical. Each of the intake hoppers, which are of concrete, has four outlets with sliding plate valves, discharging on to a short collecting conveyor. Regulation of the discharge is by means of a single handwheel, which, through a system of chain drives, opens or closes each outlet by the same amount to ensure regular and even loading of the collecting conveyor.

The collecting conveyor delivers on to the main belt intake conveyor at an angle of 90 degrees. The intake conveyor, set at an incline of 20 degrees, rises above ground level and carries the ore into the store at the apex of the roof and along a gallery running most of the length of the ridge. The total length of the intake conveyor is about 360-ft.

The ore is distributed over the storage area by a belt-driven travelling throw-off carriage. The carriage has a fabricated braced steel framework with an extended tail frame carrying troughing idlers to support the rising belt. The carriage runs on two pairs of cast-iron flanged travelling wheels running in cast-iron grease-lubricated bearings, and is driven through friction gearing from the head guide pulley. The ore is delivered through a two-way chute to both sides of the conveyor and falls to the storage dumps below through steel grids. The total travel of the throw-off carriage is 131-ft. and is such that when the store is fully loaded the shape of the dump will be determined by the natural angle of repose of the ore and the dump will bear only on the floor and load-carrying walls of the store.

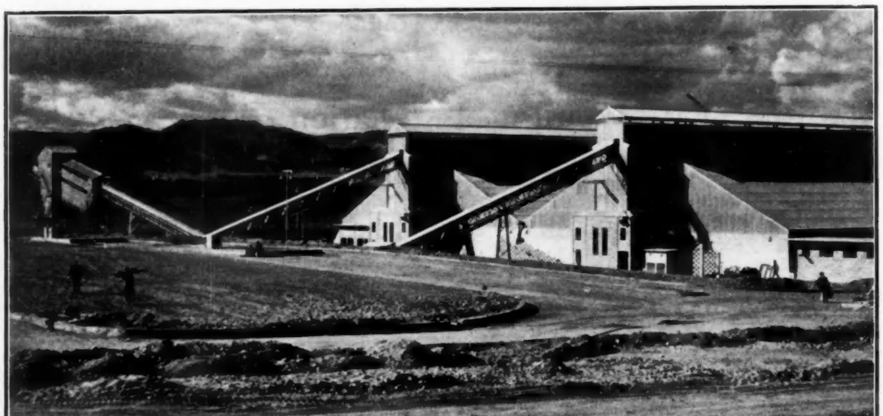
A timber walkway with guard rails where necessary runs alongside the inclined intake conveyor and along the elevated gallery.

Reclamation

Ore is reclaimed from each store on two belt conveyors running parallel to each other along the length of the store in tunnels below floor level. There are 27 outlets in staggered formation in the floor of the store, 14 to one tunnel and 13 to the other. Each outlet is equipped with a grid, a hopper, a feed-on shoe, and dust-collecting equipment. The conveyors are fed partly by gravity flow and partly by drag scraper equipment, depending on the amount of ore in store. They deliver direct on to the shipping conveyor, which runs in a tunnel along the end of the two stores, and each has a capacity of 250 tons of phosphate per hour.

The drag-scraper equipment is designed to have a capacity equivalent to that of one of the reclaiming conveyors, but its output will, of course, depend on the amount and the distribution of the ore in the store, and on the skill of the operator. The scraper has two crescent-shaped buckets arranged with their mouths facing each other, linked by a cable about 18-ft. long. Each bucket has a capacity of two cubic yards. The scraper winch is of the double-drum type, each drum being of cast-iron with gun-metal bearings, running on a steel shaft and fitted with brake and clutch paths.

The scraper buckets are positioned for operation by regulation of two travelling pulley sheaves through which the main haulage ropes passes. One sheave is mounted at each side of the store on a carriage running in monorail steelwork which extends along the entire length of the wall about 12-ft. above floor level. The sheave carriages are hauled into position by



General view of the new installation.

separate electric motor-driven winches winding steel wire rope, and incorporating special devices to relieve the carriages of strain when the scrapers are in operation.

The travelling-sheave system allows the scraper buckets to be brought into alignment with two store outlets, one to each reclaiming conveyor, simultaneously. The two outlets chosen will where possible be neighbouring ones, so that only a short haul on the scraper is necessary, but if the distribution of the ore demands it, the buckets can be brought into operation on a relatively widely separated pair of outlets.

The drag scraper equipment can be operated from two different points: duplicate sets of controls for the scraper clutch and brake, and for the travelling sheave winches, are located in the main winch house and in a cabin suspended in the store itself below the elevated gallery walkway. The operator can thus choose the more advantageous position from which to observe the distribution and movement of the piles of ore and the location of the outlets. In both positions the operator is enclosed and views operations through a window.

Flow of ore from the hopper under each of the 27 outlets in each store is regulated by a manually controlled rack and pinion valve. The ore is diverted on to the reclaiming conveyor through 90 degrees by a fixed feed-on shoe, and a branch of the dust-collecting plant is taken to each feed-on point.

Shipping-out

The shipping conveyor, which is almost 700-ft. long, begins by running horizontally in a tunnel along the end of the two stores. On emerging into the open at the edge of the seaward store it begins to rise at an angle of 12 degrees from the horizontal. A covered gantry, supported on three legs, two of which stand on piers in the water, carries the conveyor to the smaller rearmost section of the shipping tower, which houses the belt tension equipment, and through into the main section of the tower. Here the ore is delivered over the head pulley through a chute on to a short conveyor mounted on a retractable boom. The gantry above the two towers has a corrugated asbestos roof and walls.

The cantilevered front part of the tower houses a dustproof control cabin sited to give the best possible view of loading operations. A switch room with dust-proof ceiling occupies the first floor of the tower, while the third floor holds the driving gear for the final conveyor. In between is a runway for the retractable boom. When not in use the boom is winched back into the lower half of the deep gantry between the two towers by winch gear mounted at the rear end of the gantry next to the tensioning tower.

The ore is delivered by the short forward conveyor through a small hopper into the mouth of a telescopic loading chute suspended from the forward end of the retractable boom. The telescoping action of the chute is controlled both from the control room and from a cable-suspended control point operated at deck level by ship's personnel, who are thus able to suppress dust formation by keeping the free fall of ore into the ship's hold as short as possible.

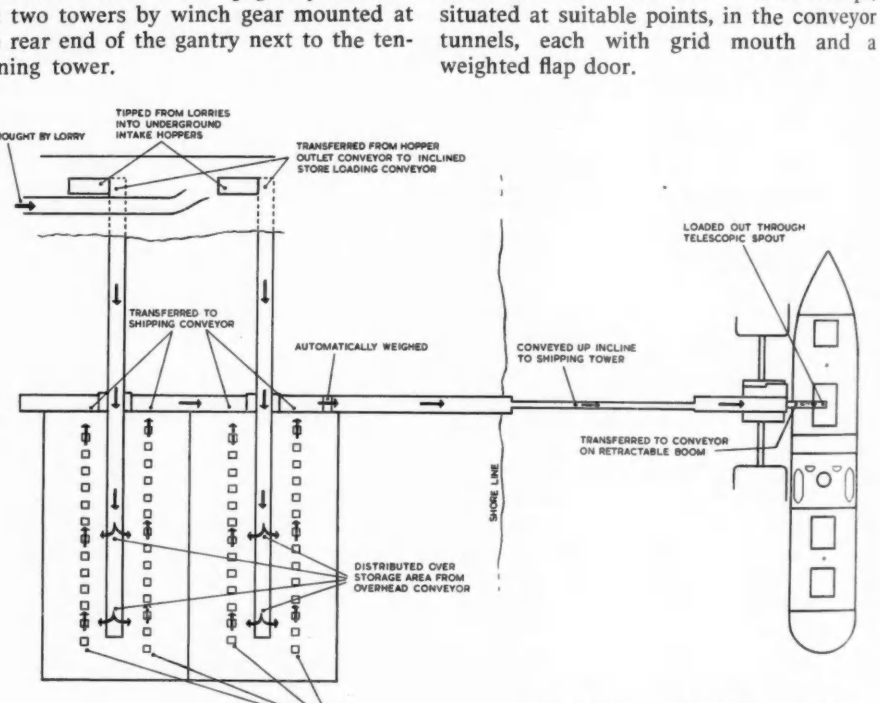
For maximum protection in rough weather the telescopic chute can be winched up a small winch mounted on the retractable boom, so that it lies parallel with the boom, and is housed inside the shipping tower when the boom is retracted.

The shipping conveyor has a capacity equivalent to that of the two reclaiming conveyors of either store—500 tons per hour.

Dust-collecting Equipment

Phosphate contains a high percentage of fines. In order to minimise the nuisance and at the same time to avoid wastage of material, each store has its own independent dust-collecting plant.

Each plant is located in a filter house at the end of the store, above the shipping conveyor tunnel between the two reclaiming conveyor delivery points. Ducting leads from each of the 27 store outlet feed-on shoes, and from the two feed-on shoes to the shipping conveyor, to a 64-sleeve suction filter. There are also 14 floor sweeps, situated at suitable points, in the conveyor tunnels, each with grid mouth and a weighted flap door.



Plan diagram showing the movement of materials through the installation.

A mild-steel fan driven through V-belting by a 50-h.p. electric motor exhausts the dust-collecting system. The fan is of sufficient capacity to exhaust the two conveyor feed-on points and any twelve of the reclaiming conveyor feed-on points, six in each tunnel, simultaneously, though it would be extremely unusual for the system to have to deal with all these points at once.

The collected dust is conveyed by a worm feed and via a small chute to the shipping conveyor at a point midway between the two main feed-on points.

Weighing

An automatic belt weighing machine to weigh and record all shipments of ore is housed in the shipping conveyor tunnel immediately forward of the last reclaiming conveyor delivery point. The weigher has a normal capacity of 500 tons per hour and an absolute maximum capacity of 66 lb/ft. For all normal working its accuracy is guaranteed to within plus or minus $\frac{1}{2}$ per cent.

The weigher incorporates a rate-of-flow indicator and an indicating and recording totaliser. The totaliser indicator consists of a numerical counter graduated from 0 to 999,999 tons, and the recording device of a type-setting and ticket printing mechanism which provides a permanent record of weighments.

The automatic steelyard and recording mechanism are mounted on a cast-iron base plate supported on the tunnel floor. The rotating portion of the recording mechanism is driven from a shaft rotated by the returning conveyor belt.

The weighing mechanism incorporates a patent device which automatically compensates for variations in the weight of the belt over different stretches. The total effect of such variations is computed over each cycle of the belt and an appropriate compensating adjustment is transmitted automatically to the totalising mechanism.

Electrical Equipment

There are over 20 electric-motor drives in the plant, ranging from the small motor driving the loading-out chute telescoping winch to the two 75-h.p. drag-scraper winch motors. The smaller motors are of the squirrel-cage type and the larger ones of the wound-rotor slipring type: all are totally enclosed and fan-cooled.

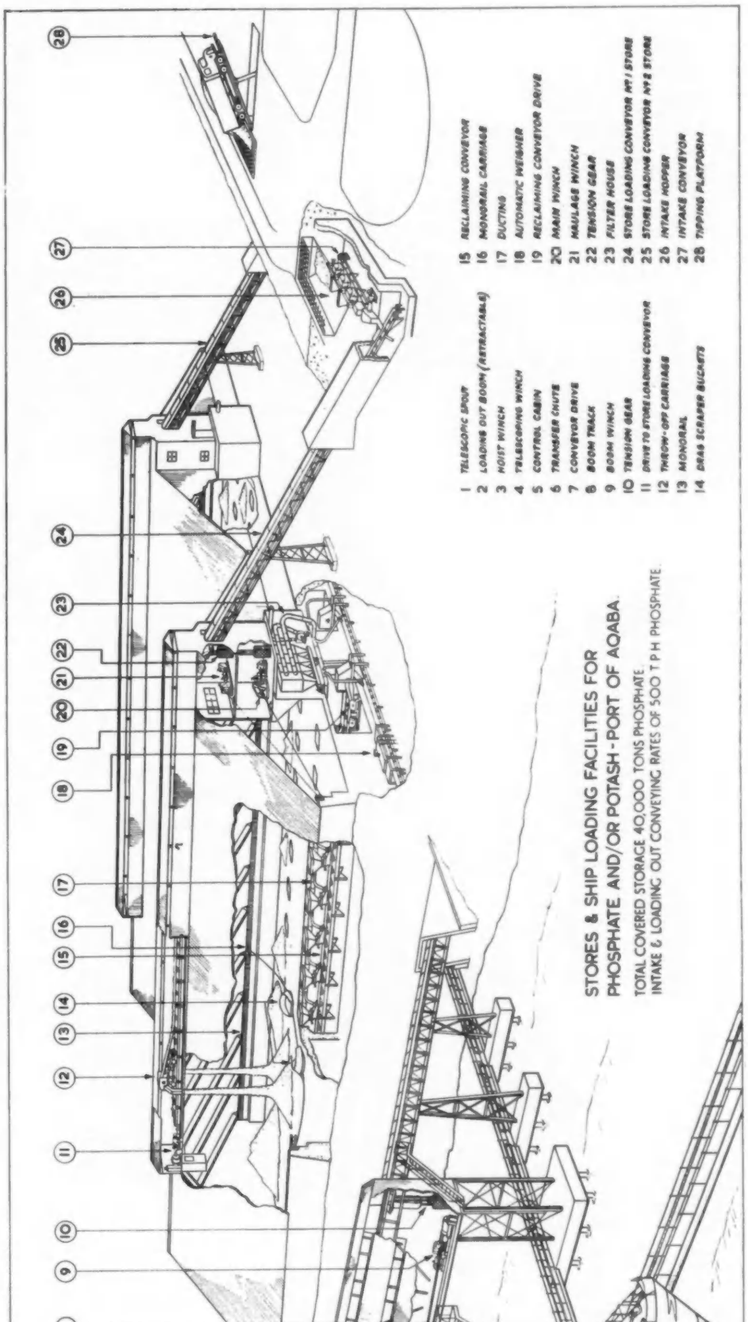
Except for the control gear for the drag-scrapers, all starters for the electric motors are of the local-operated type. Interlocking contacts are provided for machines operating in sequence.

A signalling system consisting of panel lights and audible alarm is provided for communication between the operator in the shipping tower and the operator in the shipping conveyor tunnel. This system enables the shipping tower operator to send instructions on which reclaiming conveyor, or which two conveyors of the four, the feed is to be taken from.

Provision for Future Developments

The shipping conveyor and tower have been designed to be suitable for the export of phosphate rock in addition to powdered phosphate ore, as this will probably be undertaken at some future date. It will be possible to adapt the conveyor rapidly for handling rock by removing the feed-on shoes, which are of a special slide-on variety. The lower section of the reclaimed-dust delivery chute is hinged to swing upwards and thus to leave a path for the passage of rock.

If the export of rock is undertaken, it will be stored in the open and bulldozed on to the shipping conveyor.

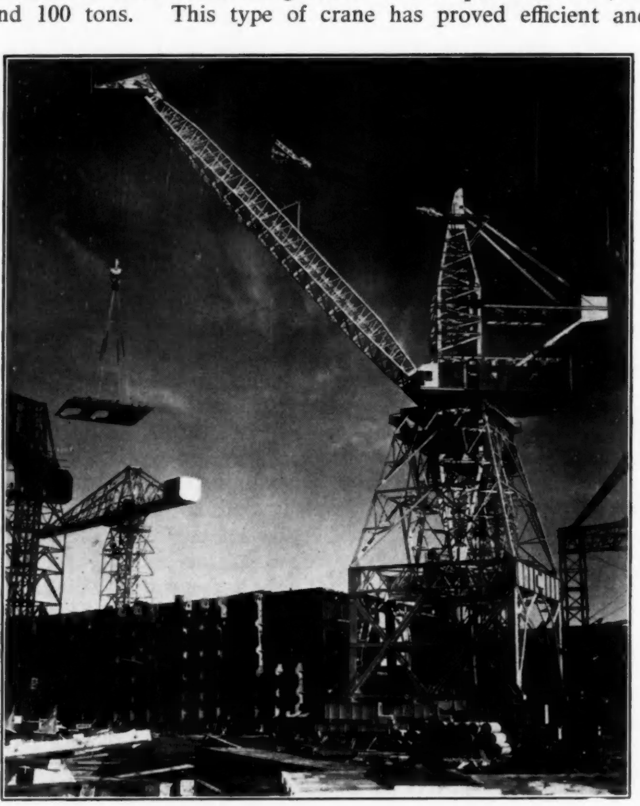


Manufacturers' Announcements

Travelling Monotower Crane for Shipyard

In recent years the methods used in shipbuilding have undergone considerable change mainly due to the great advance in welding technique. The introduction of welded prefabricated sections, which are built under cover and then transferred to the building berths or slipway has improved the output in all the shipbuilding yards using this method. In modernising their Birkenhead yards, Cammell Laird and Co. Ltd. have designed a layout which takes advantage of these new methods of construction. One of the problems they had to face, however, was to find an efficient way of transferring the large prefabricated sections weighing up to 100 tons from the welding bays to the slipway for building into the completed ship.

After extensive consideration, it was decided to use "Butters" monotower electric travelling cranes with capacities of 15, 50 and 100 tons. This type of crane has proved efficient and



The new travelling monotower crane.

economical in shipyards throughout the world, and the first of the two 100 ton capacity cranes which have been ordered at a cost of over £200,000 each, was demonstrated last month at the Company's South Yard.

The base of the tower is constructed to give a portal opening 48-ft. high and 49-ft. wide thus ensuring a free passage to and from the building berths. The luffing jib is 175-ft. long, constructed throughout of aluminium alloy riveted sections and the top of the revolving mast of the crane is 214-ft. above rail level, while the point of the jib when at minimum radius is 300-ft. above rail level.

In addition to being able to lift 100 tons at 122-ft. radius, the crane is able to handle 75 tons at 132-ft. radius, 60 tons at 145-ft. and 40 tons at 160-ft. radius. There is also an auxiliary hoist which can lift up to 10 tons at 170-ft. radius. Hoisting can be carried out with a 100-ton load at 10-ft. per minute or with a 40-ton load at 25-ft./min. The auxiliary hoist can lift 10 tons at 90-ft./min. Luffing can be carried out at between 2[illegible] and 30-ft./min., slewing at 180-ft./min. and travelling at 40-ft./min., all with a 100-ton load.

The main hoist motion is driven by a 115 b.h.p. motor, which lifts the 100-ton load on a triple pulley block. The main hoist rope barrel is 10-ft. diameter and 11-ft. 8-in. long and is machine grooved to suit the 1⅞-in. steel ropes of 6/37 construction. The main hook is of the Flemish Eye type mounted on a taper roller bearing, and suspended from a triple pulley block which lifts on six falls of rope.

The auxiliary hoist is driven by a separate 95 b.h.p. motor and its hoist barrel is 3-ft. 9-in. diameter, also machine grooved to suit the 1⅛-in. rope of 6/37 construction.

The jib luffing motion consists of work and spur gearing, totally enclosed and running in oil, and is driven by a 95 b.h.p. motor. The slewing motion for revolving the superstructure, jib and load is driven by a 55 b.h.p. motor running at 720 r.p.m.

The deadweight of the revolving portion of the crane, 580 tons, is carried on a spherical roller bearing at the bottom of the mast. This type of bearing has been used to allow for the changes in alignment which occur due to the deflection of the structure and also to transmit the horizontal reaction at the base of the mast.

The travelling motion is provided by four synchronised motors each of 32.5 b.h.p. with one motor on a driving bogie at each corner of the crane.

The crane structure, apart from the aluminium jib, is of rolled steel sections and plates throughout. Welded construction is employed for the prefabricated sections in the workshops while riveted side joints have been employed. As previously stated the jib is constructed throughout of aluminium alloy sections and plates, 175-ft. between centres, and with a cantilever extension at the point of 13-ft. centres to carry the auxiliary lift. The depth of the centre is 8-ft. 6-in. over the main angles and the width 16-ft. It is constructed of two main four angle sections which are securely braced together with a system of diaphragms and horizontal bracings.

The crane driver is housed in a cabin 126-ft. above ground level, which is glazed all round to ensure an uninterrupted view of the loads being lifted. The cabin is heated and is fitted with a telephone for communication with the ground. The operator controls all motions of the crane which is driven by 8 motors.

Radiotelephone Equipment for Royal Navy

The Royal Navy has recently awarded a substantial contract to Pye Telecommunications Ltd., of Cambridge for the supply of 28-channel v.h.f. radiotelephone equipment. This is a new unit, type PTC 8306, and is designed for ship-to-shore and ship-to-ship communication. It meets the requirements of the International Maritime Hague Conference and has also received British Post Office approval.

The unit is suitable for operation from a standard 100-150 volt/190-240 volt 40-60 cycle a.c. supply and has an r.f. output of approximately 20 watts. A low/high power switch enables the transmitter output to be reduced to approximately 20 mW for short range harbour working and alignment purposes.

The equipment provides facilities for operation on 28 channels (including two guard channels) in the international marine v.h.f. band, nine for single frequency simplex and 17 for duplex working. An outstanding feature is the specially developed synthesiser unit which provides the 28 channels with the use of only 18 crystals. Facilities are also provided for automatic reversion to channel 16 and remote control from any two alternative positions over lines of up to 200-ft. in length, depending upon loop resistance. Telephone handsets are supplied for local and remote use. Full consideration has been given to the design and construction of the equipment to ensure compactness and to facilitate maintenance.

New Twin Screw Tug/Tender for Southampton

The twin screw tug/tender "Gatcombe", designed and built by John I. Thornycroft and Co. Ltd., for the Southampton, Isle of Wight and South of England Royal Mail Steam Packet Co. Ltd., entered service in July last.

Incorporating the latest developments in tug design and costing approximately £250,000 to build, the new vessel has a length overall of 136-ft., a moulded breadth of 32-ft. and a moulded depth of 14-ft. 6-in. She has a gross tonnage of 513 and free service speed of 12½ knots. Although built primarily for towing operations and capable of handling the largest liners and tankers, the vessel also provides a high standard of accommodation for passengers when used as a tender. She can carry 200 passengers and six motor cars or, alternatively, if no vehicles are carried, 400 passengers can be embarked.

Accommodation for passengers is provided in two public rooms forward: on the main deck is a refreshment lounge with a large bar and buffet at the fore end, and on the forecastle deck a lounge with large observation windows.

The main propelling machinery, which was supplied by Crossley Brothers Ltd., Openshaw, consists of two HGN. 8/45 vertical two-stroke cycle diesel engines, each of which is flexibly coupled to a Hindmarsh/MWD/oil-operated reverse-reduction gear designed and manufactured by Modern Wheel Drive Ltd. Two Pye V.H.F. radio sets are provided, one for use with the Owners' private system and the other for working in conjunction with the port information service. A Marconi "Gannet"/"Guardian" H.F. transmitter/receiver is fitted for use on the R/T shipping band.

The "Gatcombe", which replaces the 46-year old "Paladin" which has recently been sold to Dutch shipbreakers, was built at the Woolston Works of John I. Thornycroft and Co. Ltd., Southampton.

Carbon Dioxide Fire Extinguisher

The introduction of a leak-proof, strike-knob 5 lb. carbon dioxide fire extinguisher, model 1505, which is the result of several years' experiment, has been announced by Nu-Swift Ltd. The model is complementary to the 10 lb carbon dioxide extinguisher, model 1510, which was introduced in 1958.

Mainly intended for fighting inflammable liquid fires, and fires involving electrical equipment indoors, the new extinguisher has a mean range in still air of 11-ft.; the carbon dioxide being expelled for 8 seconds at 65°F. through a new type of discharge diffuser. It has been designed for fire fighting at close quarters and, operated in the hands of an inexperienced fighter is capable of putting out a 6 sq. ft. inflammable liquid fire. In the case of an experienced operator, the figure is 9 sq. ft.

Carbon dioxide, although much less efficient than dry powder for fire fighting, is non-damaging in use, leaves no residue and can be made to penetrate into places which are inaccessible to other fire-fighting media. It can be reloaded in 60 seconds. It is invaluable, therefore, for fighting fires involving fine chemicals or complicated electrical or electronic equipment ashore or on board ships. This model has been approved by the Ministry of Transport (Marine Section) for use on merchant vessels.

Self-Propelled Grain Handling Plant

A new model of a self-propelled, self-powered grain handling plant has been developed by Simon Handling Engineers Ltd., Stockport, Cheshire, and the first plant of this type was despatched recently to South Africa for the East London Stevedoring Company.

This new plant can be employed on a variety of grain handling operations at rail, road and dock transfer points and has high speed mobility, and a useful capacity of 37½ tons of grain per hour, providing a versatility and all-round performance which should prove invaluable to many grain handling organisations.

The pneumatic handling equipment is mounted on a Leyland Beaver chassis powered by the Leyland 680 six-cylinder 150 h.p. diesel engine, and is driven from the vehicle power take-off unit through a Turbine Gears reduction unit.

The conveying airstream is provided by a Roots-type exhauster mounted centrally on the vehicle platform. The grain is conveyed under suction from the vessel or vehicle being unloaded into a large grain receiver mounted near the rear of the vehicle. Here the grain falls out of suspension, while the air is drawn through a cyclone dust collector. The air is cleaned further in an air receiver on the suction side of the exhauster. The grain and dust are discharged from the receiver through a rotary seal which preserves the vacuum, into a delivery pipe through which they are blown to their destination.

The total distance over which grain can be conveyed is 150-ft., and this can be divided into suction and blowing lines of equal or varying lengths, to suit the circumstances. The conveying lines necessary for each job are readily assembled from lengths of flexible piping, which are stacked on the platform when not in use. A regulating valve fitted on the suction nozzle enables the air intake to be adjusted to suit the length of the suction line.

The new mobile grain handling plant.

An alarm system and automatic release valves protect the plant against blockage or jamming. If the revolutions of the rotary seal fall below a certain figure owing to blockage, a rotational control unit which is geared to it comes into operation: delivery of grain is automatically suspended, and a klaxon alarm sounds until the engine is throttled down.

The plant is fully instrumented, allowing a check to be kept on correct efficient operation, and enabling faults to be located promptly.

A collapsible derrick with pulley block is provided to support the blowing line for the delivery of grain to a raised point such as the top of a railway wagon.

Dredger for King's Lynn

Richard Dunston Limited have launched from their Hessle Shipyard a grab hopper dredger, ordered by the British Transport Commission for operation at King's Lynn.

The "Breckland" will be used to improve the entrance to the docks which, in recent years, has been subject to silting. It has a single Priestman grab located forward which is capable of working over the bows. The hopper has a capacity of about 350 cu. yds. and is fitted with ten hydraulically operated doors.

Dockside Cranes for Tees Conservancy Commission

An order for 10 level-luffing dockside cranes for Tees Dock, No. 1 Quay has been received from the Tees Conservancy Commissioners by Clyde Crane and Booth Ltd. The cranes will be of the latest Clyde Hydral-Luff design which features a self-contained low-pressure electro-hydraulic system for operating the luffing motion, and will be the mast type with carriages in the form of a streamlined portal frame, a feature which improves the appearance and effects economies in time and costs of maintenance painting.

All the cranes have two-speed hoists and are arranged for both grabbing duties and general cargo handling, eight being of 6/3 tons and two of 10/6 tons capacity. The maximum radius on all the cranes is 80-ft. The 6-ton cranes have a hoisting speed of 150-ft./min.; the 3-ton 300-ft./min.; the 10-ton 90-ft./min. The range of lift in each case is from 75-ft. above to 55-ft. below rail level at maximum radius. The quay rail gauge is 18-ft. and all the portals are mounted on four two-wheel fully equalising compensating bogies.

First Automatic Lighthouse for India

The first fully automatic all-electric lighthouse equipment for the Government of India has been successfully tested at the Crawley Works of Stone-Chance Ltd. This equipment has been designed to operate completely unattended for periods of 6 weeks at which intervals it will be visited by an inspector. The optical system consists of an 8 panel revolving lens with red screens to give four groups of double flashes per revolution. The lens is rotated on a mercury bath pedestal by a weight driven machine fitted with duplicate electric rewind motors, the one acting as standby to the other.

The power of the lens is 24,000 candelas (red) giving a visible range in clear weather of 24½ sea miles. An automatic lamp-changer provides two spare lamps, either of which is brought into operation instantaneously in the event of main lamp failure.

Control switchgear is housed in a cubicle together with two electrically wound time-clocks operating in parallel. These provide basic control of the installation. The equipment will be installed at East Point, Lat. 170°41'N by Long. 83°19'E.